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AN INVESTIGATION OF CONDITIONED FEEDING RESPONSES AND CONCOMITANT ADAPTIVE BEHAVIOR IN YOUNG INFANTS

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FOREWORD

Dr. Kantrow's investigation, the fourth monograph to appear in Professor Irwin's series of researches on infant behavior, gives a clear-cut account of the laboratory controls which may be combined effectively to elicit and analyze conditioned responses in infants. Spontaneous sucking was produced, utilizing the sound of a buzzer as a conditioned stimulus, in from three to nine feedings comprising sixteen to fifty-three paired stimulations. (The infant's food was the unconditioned or conditioning stimulus.) Stability of response was achieved in from one to five days.

Throughout the experiment, which involved both conditioning and unconditioning (extinction), the prime motivating factor was hunger. Satiation prevented conditioning. The behavior of these infants under four months of age included performances modified to meet changing environmental needs in a fashion consistent with a concept of intelligence at later ages.

George D. Stoddard

Office of the Director
Iowa Child Welfare Research Station
University of Iowa
March 11, 1937

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CHAPTER I

INTRODUCTION*

To discover at what age and to what stimuli the infant can be conditioned has been the aim of a number of investigations. Marquis (12) reported the elicitation of conditioned feeding responses to an auditory stimulus by the fifth postnatal day. Wenger (21) also investigated the possibility of neonatal conditioning. Using a variety of objective experimental techniques, he was led to the conclusion that the conditioned response is difficult to elicit within the first ten days of life and that it is unstable when it does appear. The age of appearance of conditioned feeding responses to auditory and visual stimuli was studied in eleven infants less than three months of age by Denisova and Figurin (2). These authors found that conditioned responses appeared from 33 to 77 days after birth. Razran (15) states in his report of this study that conditioned responses appear to be formed earlier to auditory than to visual stimuli. Levikova and Nevymakova (11) obtained stable conditioned food responses to an auditory stimulus at 66 to 110 days after birth in five infants who ranged in age from 14 to 86 days at the onset of the investigation. In addition, they elicited differential conditioned responses in four of these infants at 110 to 112 days. Two studies recently reported by Kasatkin and Levikova (8, 9) state that conditioned feeding responses were formed in three infants to an auditory stimulus at 34 to 43 days after birth, and in six infants to a visual stimulus at 57 to 61 days after birth. These authors also reported the elicitation of differential conditioned responses to visual and auditory stimuli. Jones (7), using an electric shock as the unconditioned stimulus and a light, a touch, and a variety of sounds as the conditioned stimuli, established a conditioned psychogalvanic reflex in three infants three to nine months of age after six to fourteen combined stimulations. The results of the above studies indicate that stable conditioning to a variety of stimuli may be obtained by at least the third postnatal month. In this connection, it is of interest to mention a study of bladder control reported by Scoe (16). He states in his training program for bladder control

* This study was directed by Professor Orvis C. Irwin.

that the most effective manner of establishing this behavior is to condition the eliminative functions to the tactual stimulation of the chamber and to the sound of the training word. His results indicate that significant gains in the training of this function can be made from the third month after birth.

Since the possibility of conditioning young infants has been established, this investigation was designed to analyze the organization of early adaptive behavior, using the technique of the conditioned response. Hull (6) has stated that the greatest significance of the principles discovered by conditioned response experiments lies in their application to the interpretation of more complex behavior.

This investigation seeks to answer the following questions. What is the rate of the acquisition of the conditioned response, and with what concomitant behavior is the acquisition of the conditioned response associated? Of what influence is the strength of the underlying physiological state of hunger upon the strength of the unconditioned and conditioned responses? Does the concomitant behavior associated with the conditioned response show the anticipatory character of conditioning? What is the rate of experimental extinction? Of what significance is the behavior associated with the extinctive process?

The spontaneous sucking of the infant was selected as the behavior to be conditioned because experimental evidence indicates that the conditioned feeding response is relatively easy to elicit. An auditory stimulus was chosen for the conditioned stimulus since there is evidence that during the early months of life auditory stimuli are more effective than visual stimuli in eliciting conditioned feeding responses. The food presented to the infant represented the unconditioned stimulus.

CHAPTER II

DESCRIPTION OF SUBJECTS, APPARATUS, AND EXPERIMENTAL PROCEDURE

Subjects

Sixteen infants at the Saint Vincent's Orphanage in Chicago served as subjects in this investigation.[1] There were ten boys and six girls. The ages at the time of the first experiment ranged from one month, fourteen days to three months, twenty-seven days. All children at the institution were under daily medical inspection, and no infant was taken from the nursery for the experimentation unless it was in good physical condition. The new revision of the Kuhlmann-Binet test was given to fifteen of the infants. The IQ's ranged from 88 to 125, indicating that the infants were within the normal range of intelligence.

Description of the Apparatus and Data Obtained

Records were obtained of sucking movements, and observations were made of the general behavior of the infants. Figure 1 shows the apparatus used for the recording of the sucking movements. A headrest, so constructed as to prevent gross lateral movements of the head, was used. A chin-harness of linen, made to fit snugly the chin of the infant, was connected by light strings to a roller cross-pin through small holes drilled near the ends of the pin. The roller-pin was supported upon the headrest above and behind the infant's head. A weight was suspended by a string tied through a hole drilled into the center of the roller cross-pin. One rotation of the pin was made to wrap the weighted string about it. Any slack in the chin-harness strings attached to the pin was therefore rolled upon the pin. Thus at all times during an experiment a sufficient force exerted by the weight maintained the chin-harness under slight tension and responsive to the chin movements of the infant. In this manner the roller cross-pin was rotated with every chin movement. This rotary movement of the pin was transmitted by another weighted string over a pulley through whose axis a record-

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[1] The infants used in this investigation were made available by Dr. M. L. Blatt and Sister Agatha of Saint Vincent's Orphanage, Chicago, Illinois, for whose kind cooperation and interest the author is deeply grateful.

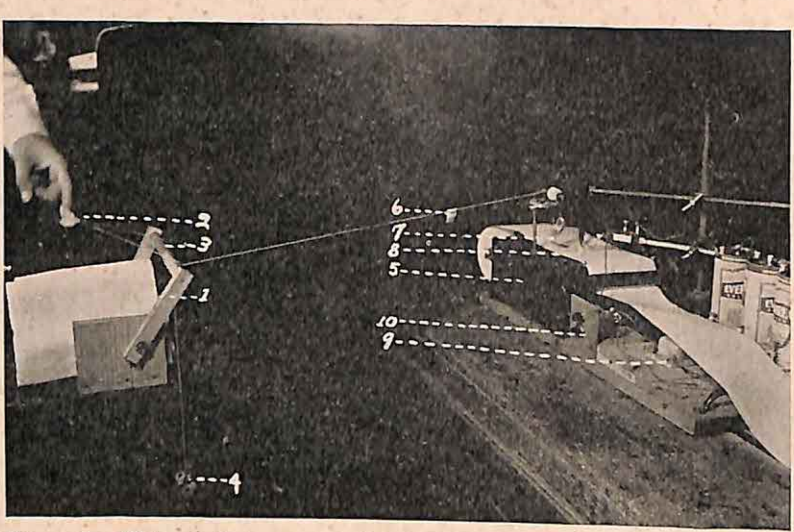

Figure 1. Picture of Apparatus (1 = Headrest; 2 = Chin-Harness; 3 = Roller Cross-Pin; 4 = Weight Which Maintains Chin-Harness Under Slight Tension; 5 = Polygraph; 6 = String Weighted Over Pulley Through Whose Axis Recording Polygraph Pen Is Fixed; 7 = Polygraph Pen Recording Sucking Movements; 8 = Polygraph Pen Recording Buzzer Stimulation Intervals; 9 = Buzzer; 10 = Buzzer Switch)

ing polygraph pen was fixed. Thus the chin movements were transmitted to the pen. A second polygraph pen recorded the stimulation intervals. This pen and the conditioned stimulus, a buzzer, were wired in series so that the initiation of the buzzer sound, by the turning of a switch, was indicated by a displacement of the pen from its base line. The pen was maintained at its new position for the duration of the buzzer sound. At the cessation of the buzzer sound, the pen returned to its base line. Figure 2 illustrates sucking records obtained with the recording apparatus.

Protocols of crying, general body activity, states of wakefulness, and refusals of milk by the infants were made on the moving polygraph paper. The following notations were made of general body activity: *slight activity*, by which is meant that state when the infant's movements were confined to the head and upper extremities; *marked activity*, by which is meant that state when the infant's movements were generalized and included the lower extremities; *crying*, which included whimpering and crying. The degree of activity during crying was never differentiated. In the differential behavior protocols, slight activity and marked activity never

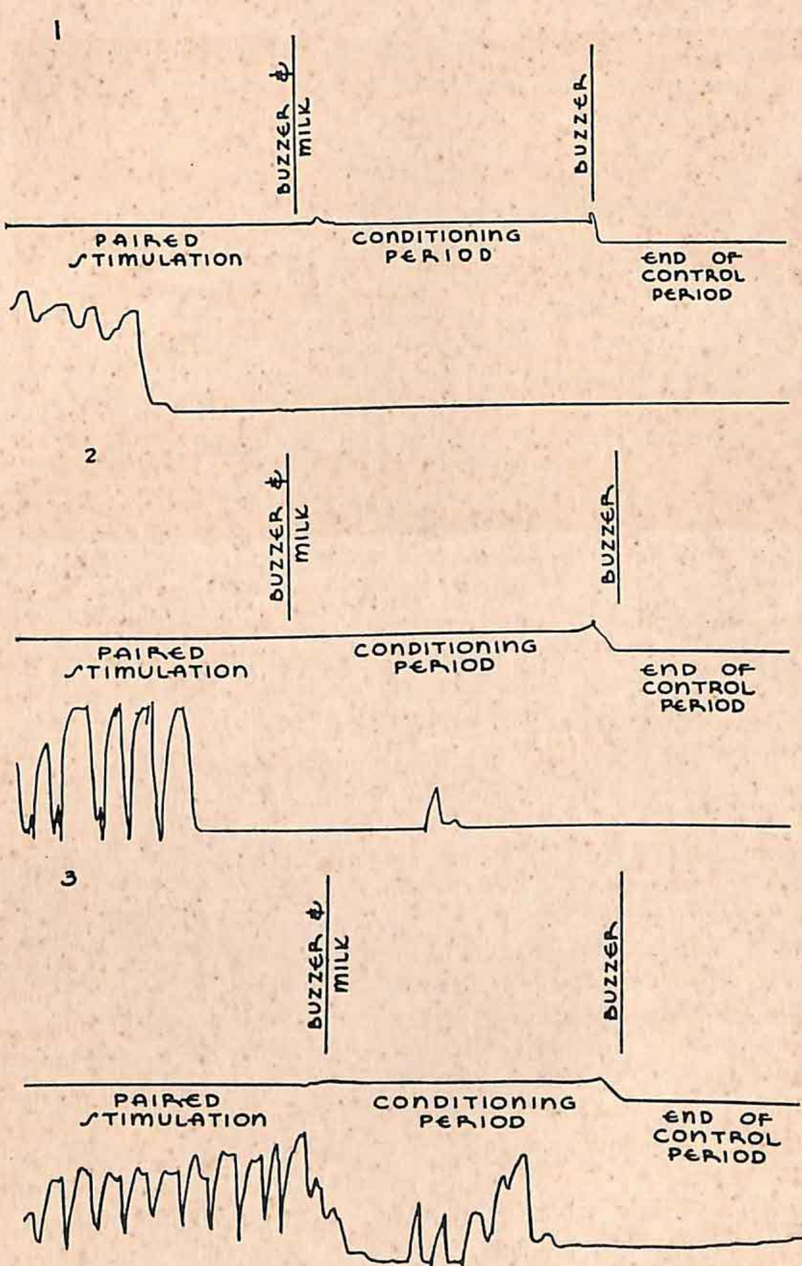

Figure 2. Sample of Sucking Records Obtained from the Records of M6 (No. 1. First experimental feeding, fifth paired stimulation; No. 2. Fifth experimental feeding, thirty-second paired stimulation; No. 3. Eighth experimental feeding, fifty-fourth paired stimulation)

included crying states. The reliability of these observations was checked by an assistant observer for three feeding periods. There was a 96 per cent agreement on the frequency of behavioral changes observed and a 92 per cent agreement on the character of these changes.

The experiments were conducted in a large, light room which was used exclusively for this investigation. The room was sufficiently distant from the nurseries to exclude the nursery noises. With this exception, no attempt was made to control environmental factors.

Cinematographic records were obtained. The film includes a description of the recording apparatus, the method employed, and the elicitation of stable conditioned responses from two infants. This film is on file at the Iowa Child Welfare Research Station.

Experimental Procedure

In the routine of the Saint Vincent's Orphanage, infants were fed at four hour intervals, the first feeding being at 6 a.m. With the exception of several of the younger ones, the infants used in this investigation did not receive a feeding at 2 a.m. The experiments were conducted during the 10 a.m. and 2, 6, and 10 p.m. feeding periods. Two or three infants were used during a single feeding period. An experimental feeding lasted about twenty minutes.

At the feeding period, the infant and his feeding bottle were taken from the nursery to the experimental room. The infant was wrapped in a restraint sheet to minimize gross body movements, his head placed in the headrest, and the chin-harness adjusted. With the infant in position, the polygraph was set in motion. From this point until the conclusion of the experiment, records of sucking movements and protocols of the general behavior of the infant were obtained.

The following sequence was used four to twelve times during an experimental feeding in the establishment and the continued elicitation of the conditioned feeding response:

1. Control Period: These periods during each experimental feeding lasted from 25 to 75 seconds, with the exception of the initial control period which lasted from 60 to 120 seconds in order that the infant could become adjusted to the experimental situation. The length of the control periods was varied to avoid the possibility of establishing a conditioned response to a temporal sequence.

2. Presentation of the Conditioned Stimulus: A buzzer tone was applied for a period of five seconds at the end of every control period in all the experiments. Henceforth, this interval will be called the conditioning interval.

3. Reinforcement of the Conditioned Stimulus: After the conditioned stimulus had been presented alone for five seconds, the milk bottle, which until this time had been held outside the infant's field of vision, was inserted into the infant's mouth and the milk and the buzzer were presented together for fifteen seconds. These paired stimulations, the buzzer and the milk, constituted the reinforcement period.

4. Presentation of the Unconditioned Stimulus Alone: During this last period the unconditioned stimulus, milk, was presented alone for periods ranging from 15 to 120 seconds.

This sequence of control period, presentation of conditioned stimulus, reinforcement, and unconditioned stimulus alone, was repeated until the infant had consumed the entire feeding or had persistently refused the feeding. As far as was possible, the infant was used at the four experimental feeding periods during the day until the conditioned feeding responses were stable.

In those experiments in which the conditioned response was experimentally extinguished, the above described sequence was first followed from two to five times to assure the presence of the conditioned feeding response. This preliminary elicitation of the conditioned response was associated with the consumption of approximately one-third the total feeding. The infant was thus only partially fed in order to be reasonably certain that the hunger state had not completely disappeared. At this point experimental extinction was undertaken. The buzzer alone, unreinforced and not followed by the unconditioned stimulus, was presented for five seconds. This unreinforced presentation of the conditioned stimulus was followed by a control period which lasted from 30 to 60 seconds. This sequence of control period and unreinforced buzzer was repeated until no sucking was elicited in three consecutive presentations of the buzzer. Experimental extinction was never performed until the conditioned feeding response was stable.

CHAPTER III

ACQUISITION AND COURSE OF THE CONDITIONED FEEDING RESPONSE AND THE CONCOMITANT BEHAVIORAL CHANGES

Criterion of Conditioning

Since spontaneous sucking movements occurred during the control periods of all subjects, it became necessary to differentiate this spontaneous sucking from the sucking which appeared as a conditioned response to the buzzer. The most critical analysis that could be made was to compare the amount of sucking during the five second conditioning period with the five consecutive seconds within the entire control period which contained the most sucking. This interval will hereafter be called the critical control period. It is evident that the position of the critical control period within the entire control period and its temporal relationship to the buzzer period will vary, because the selection of this interval was dependent solely upon the concentration of the spontaneous sucking movements. Since the critical control period represents the greatest amount of spontaneous sucking during five seconds, within a period which lasted five to twenty-four times as long as the conditioning period, it serves to differentiate sharply, spontaneous from conditioned sucking responses. The difference between the number of sucks in the conditioning period and the number of sucks in the critical control period served as the standard by which the degree of conditioning was determined. Therefore, any degree of sucking during the conditioning period which is in excess of the sucking observed during the critical control period may be considered as evidence for the appearance of the conditioned feeding response.

To determine the acquisition of the conditioned response, the difference between the means of the sucking movements in the critical control periods and the conditioning periods was obtained for each experimental feeding. Conditioning was considered to be established when the difference between the mean amount of sucking in the conditioning period continued to exceed the mean amount observed during the critical control period for consecutive experimental feedings.

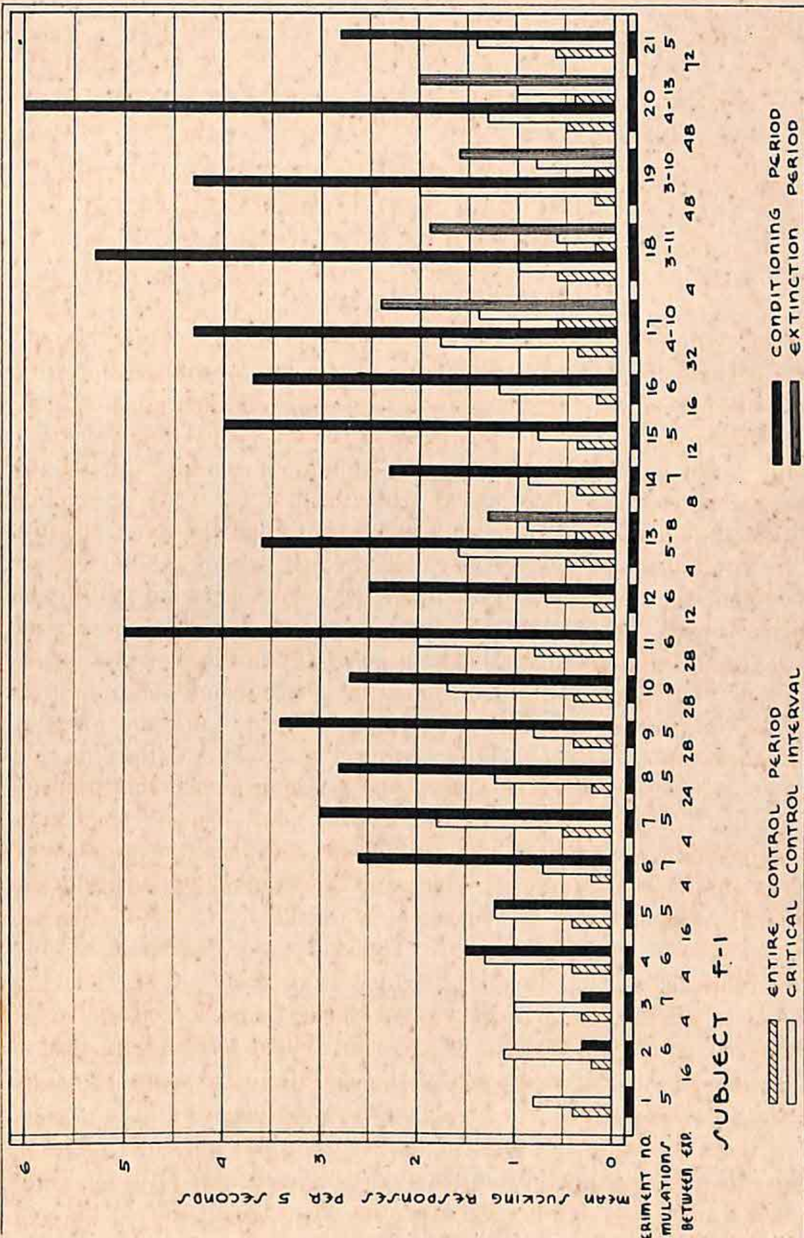

Figure 3. Mean Sucking Responses During Each Experimental Feeding for Subject F1

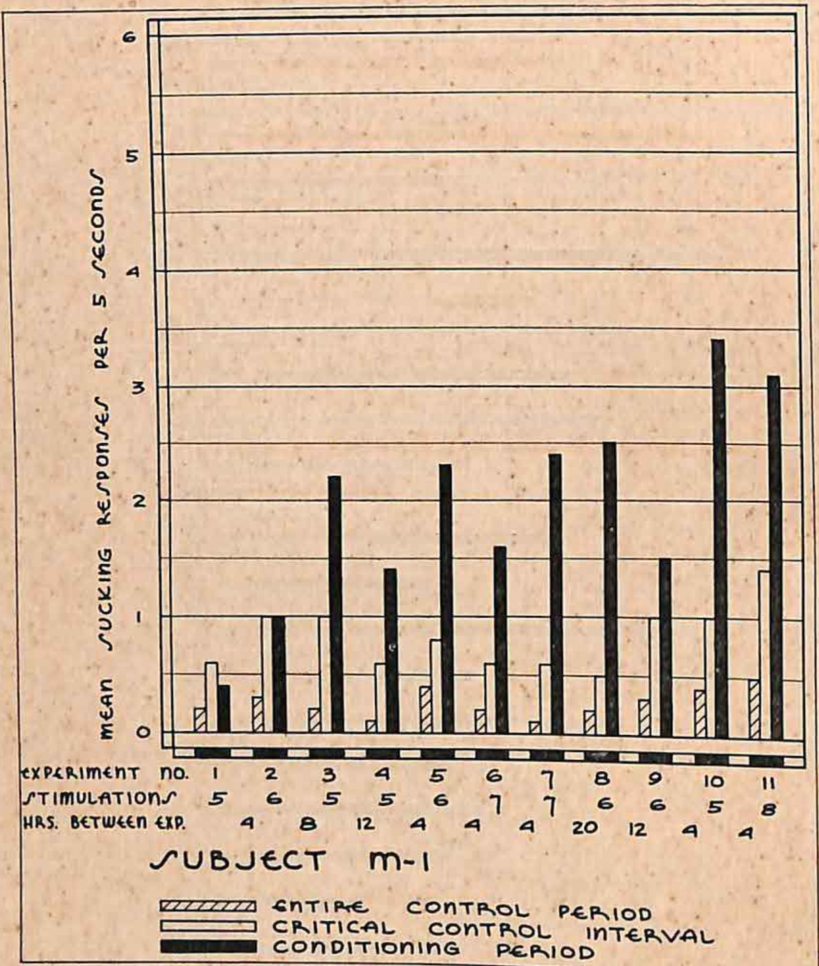

Figure 4. Mean Sucking Responses During Each Experimental Feeding for Subject M1

Figures 3 through 18 show that the ranges of the amounts of spontaneous sucking during the entire control period and the critical control period are fairly narrow for each infant during all the experimental feedings. The process of conditioning is manifest by the progressive increase in the frequency and vigor of the sucking movements during the conditioning period. From a frequency below the level observed in the critical control interval, the frequency of the sucking response during the conditioning interval increases until

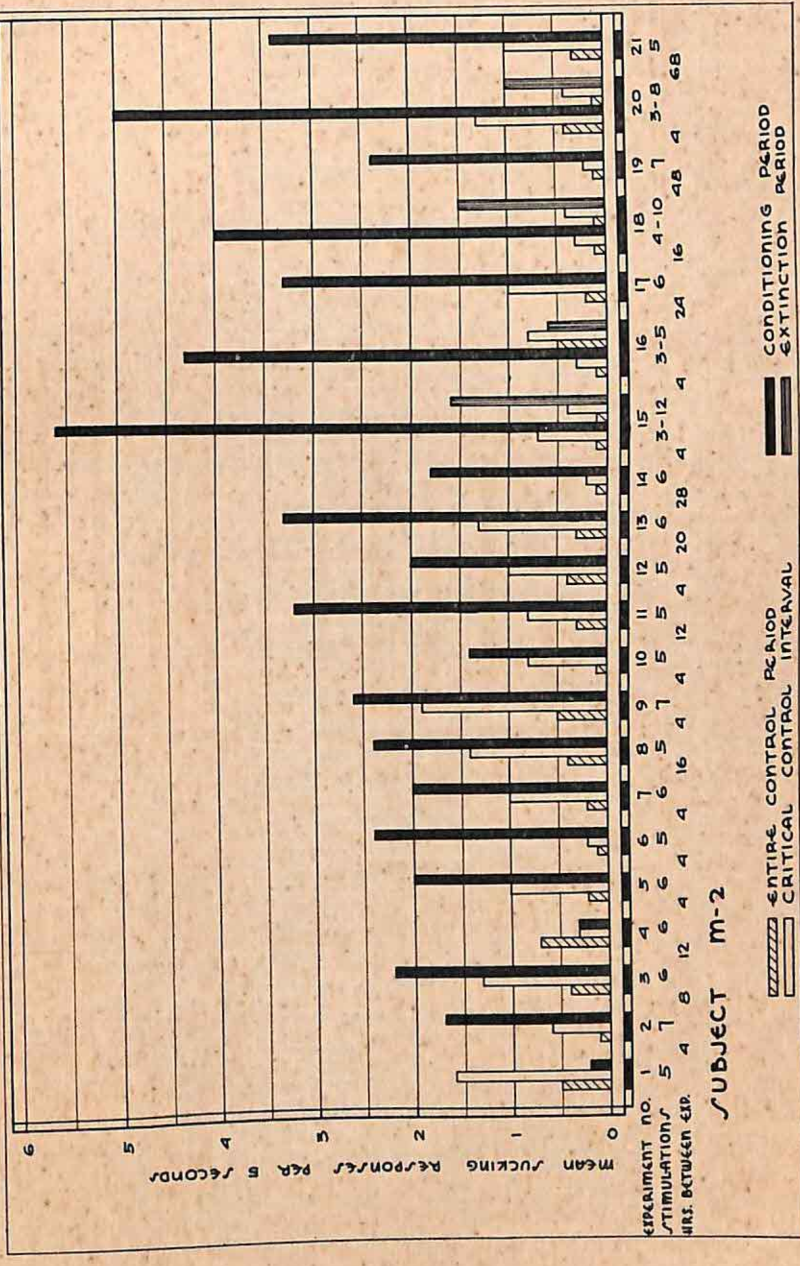

Figure 5. Mean Sucking Responses During Each Experimental Feeding for Subject M2

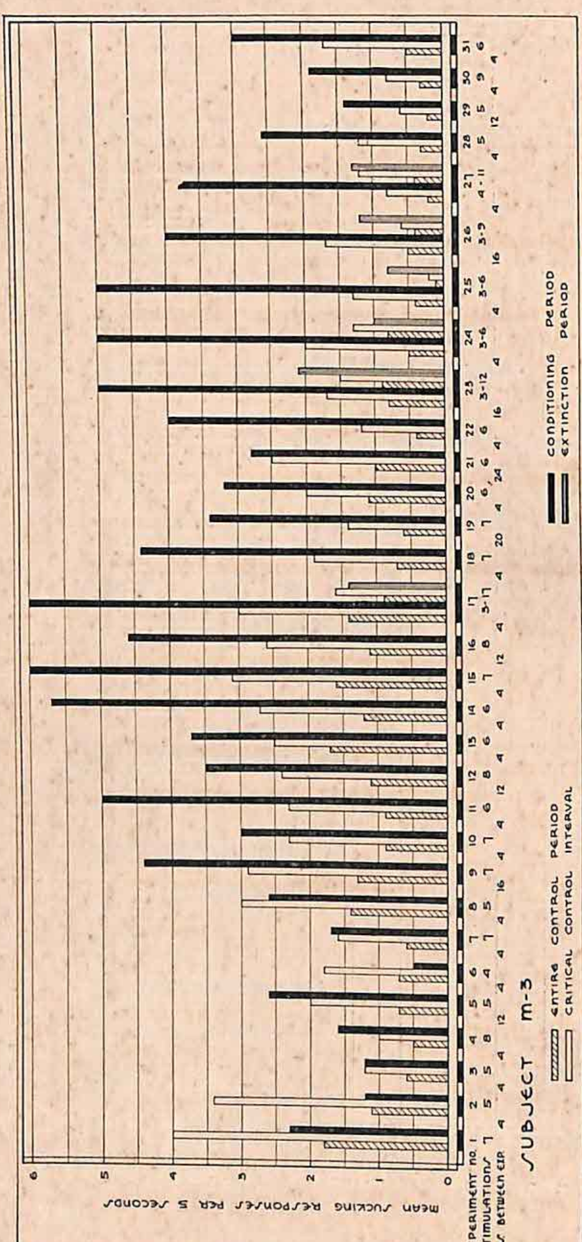

Figure 6. Mean Sucking Responses During Each Experimental Feeding for Subject M3

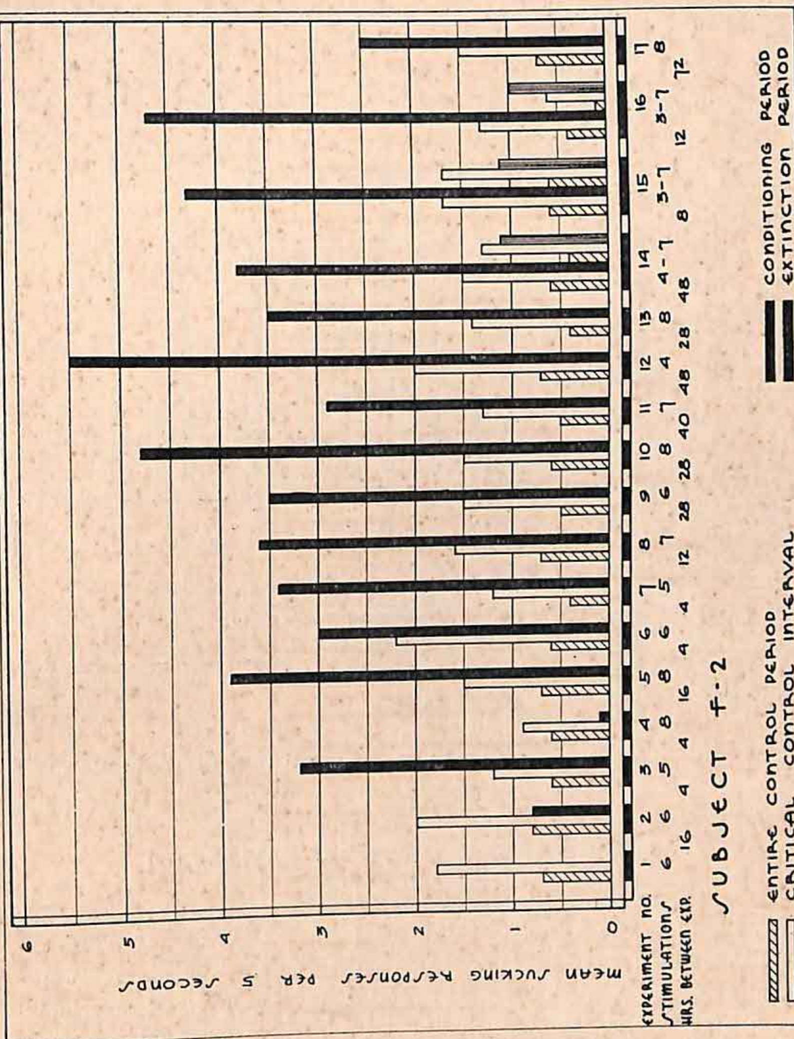

Figure 7. Mean Sucking Responses During Each Experimental Feeding for Subject F2

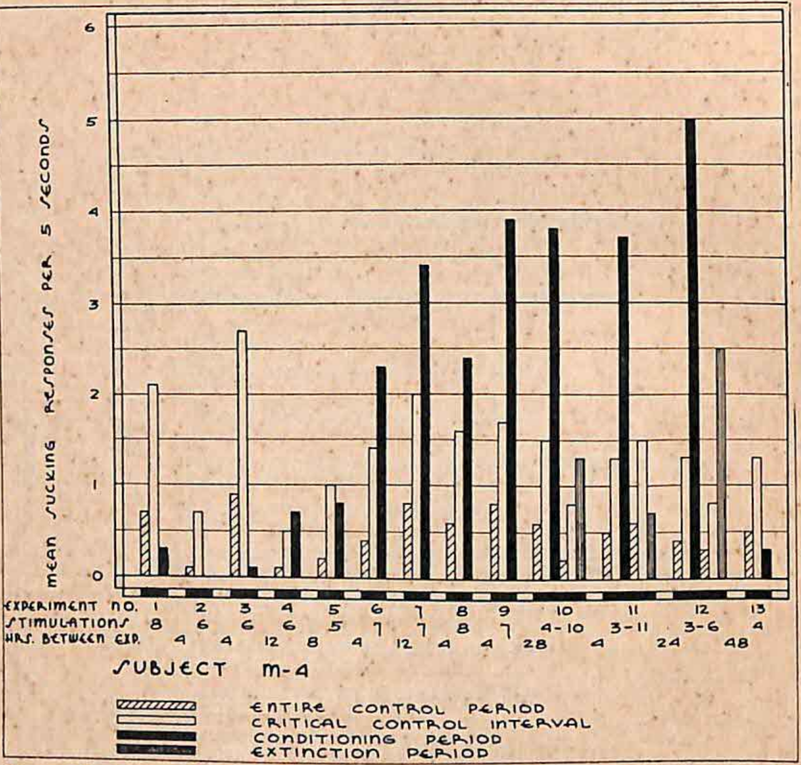

Figure 8. Mean Sucking Responses During Each Experimental Feeding for Subject M4

it equals that of the critical control interval and finally exceeds it when stable conditioning appears.

Age at Establishment of the Conditioned Sucking Response

From Table 1 it is noted that the age at the time of the first experiment ranged from forty-four to 117 days. The stable conditioned feeding response was present after three to nine experimental feedings which contained sixteen to fifty-three paired stimulations. The age at the establishment of the conditioned feeding response ranged from forty-six to 118 days. One to five days were required to produce stable conditioning with the procedure used in this investigation. The rapidity with which the conditioned feeding response was acquired, in terms of the number of feeding ex-

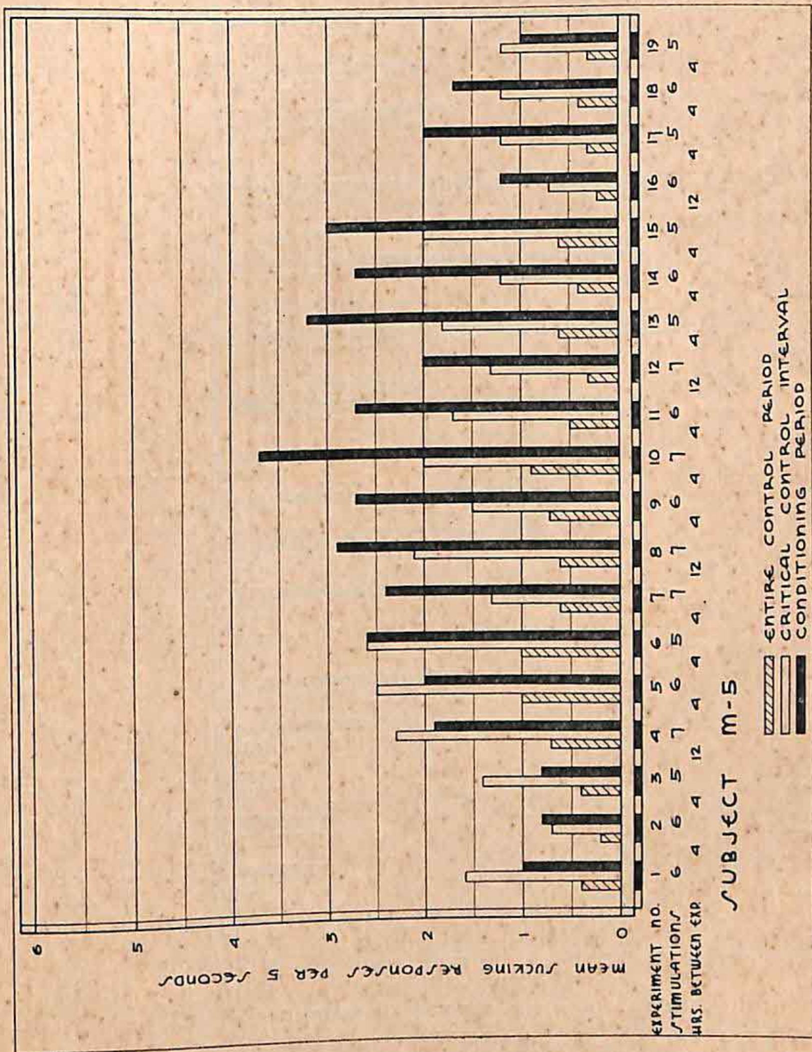

Figure 9. Mean Sucking Responses During Each Experimental Feeding for Subject M5

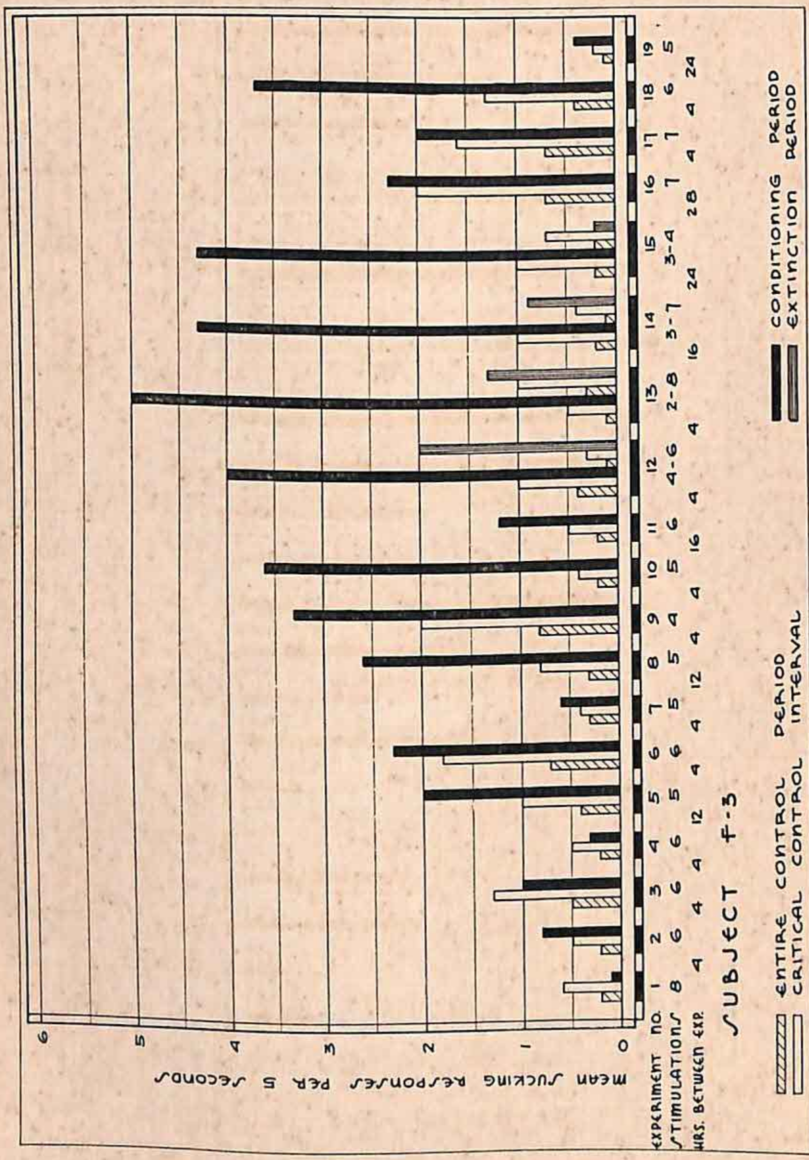

Figure 10. Mean Sucking Responses During Each Experimental Feeding for Subject F3

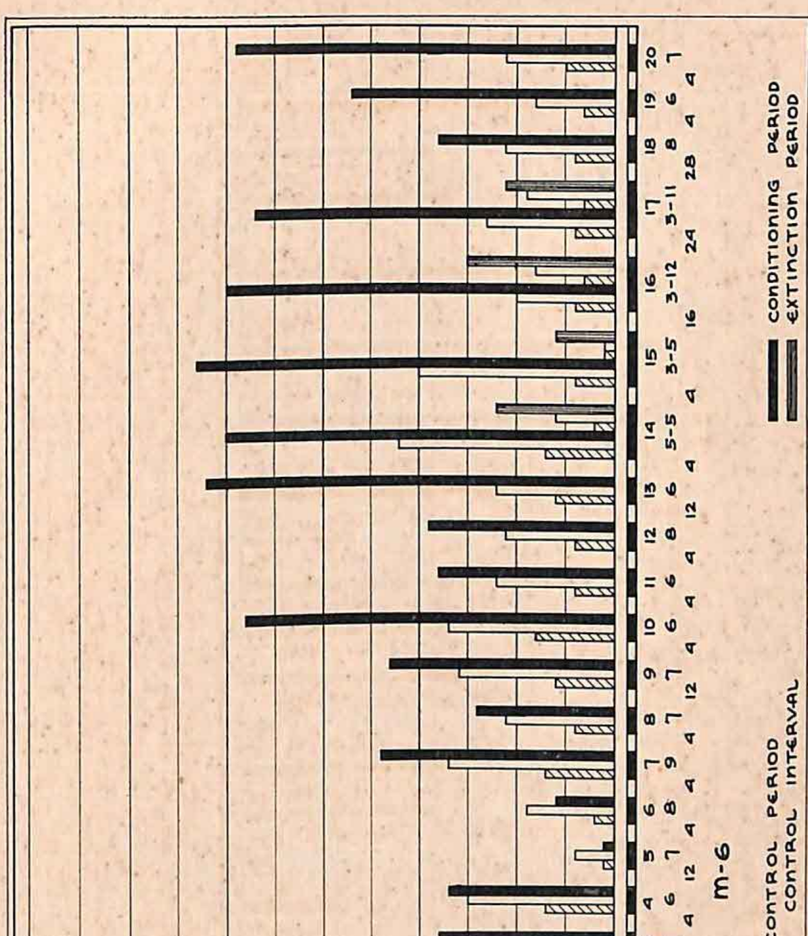

Figure 11. Mean Sucking Responses During Each Experimental Feeding for Subject M6

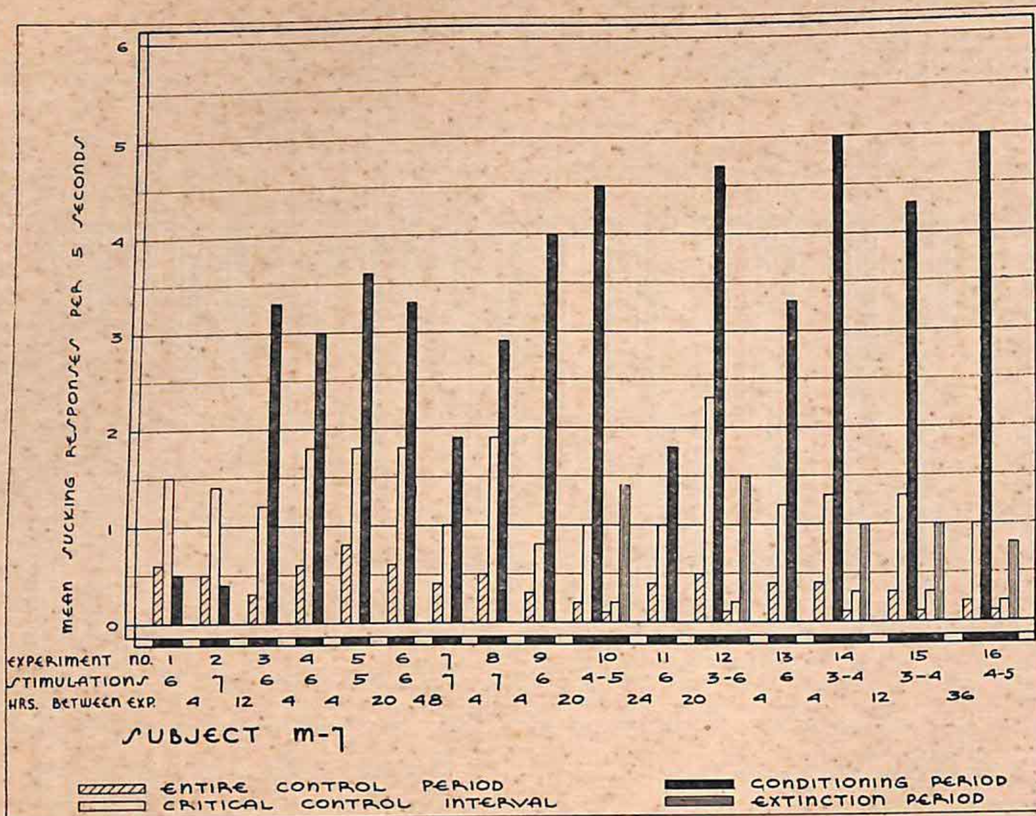

Figure 12. Mean Sucking Responses During Each Experimental Feeding for Subject M7

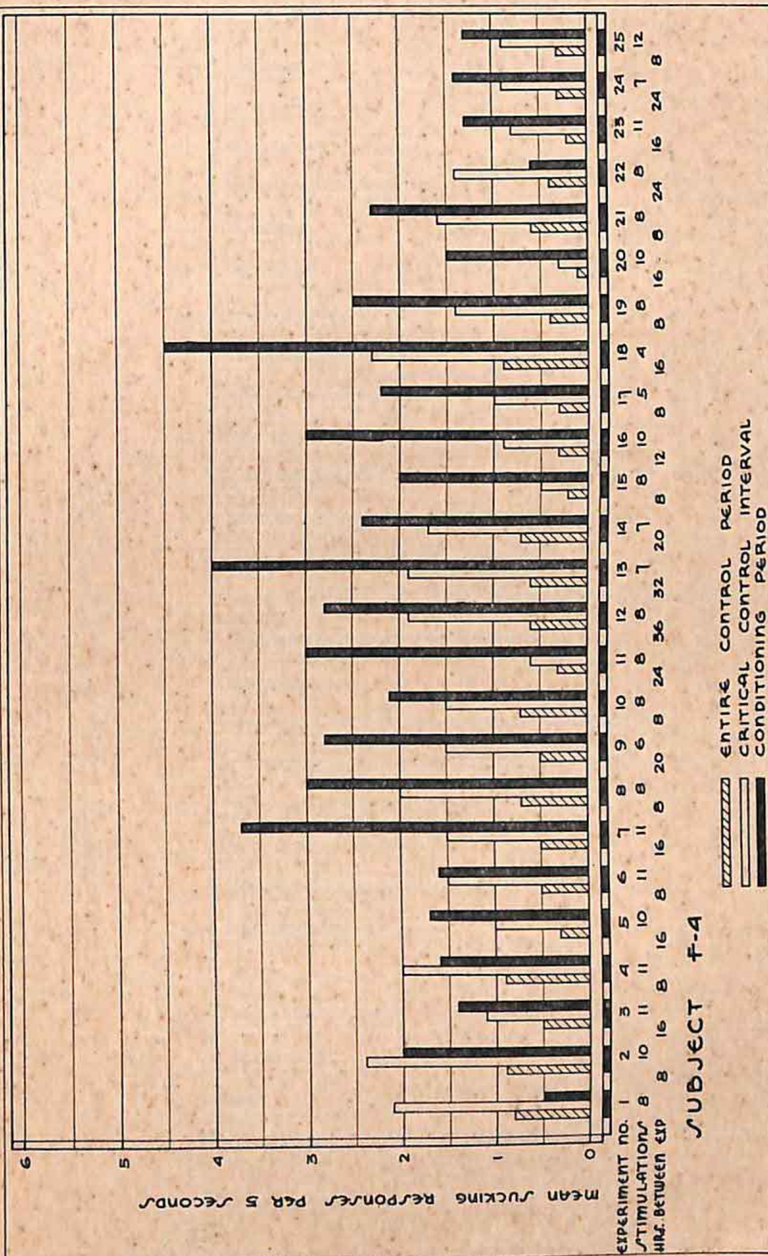

Figure 13. Mean Sucking Responses During Each Experimental Feeding for Subject F4

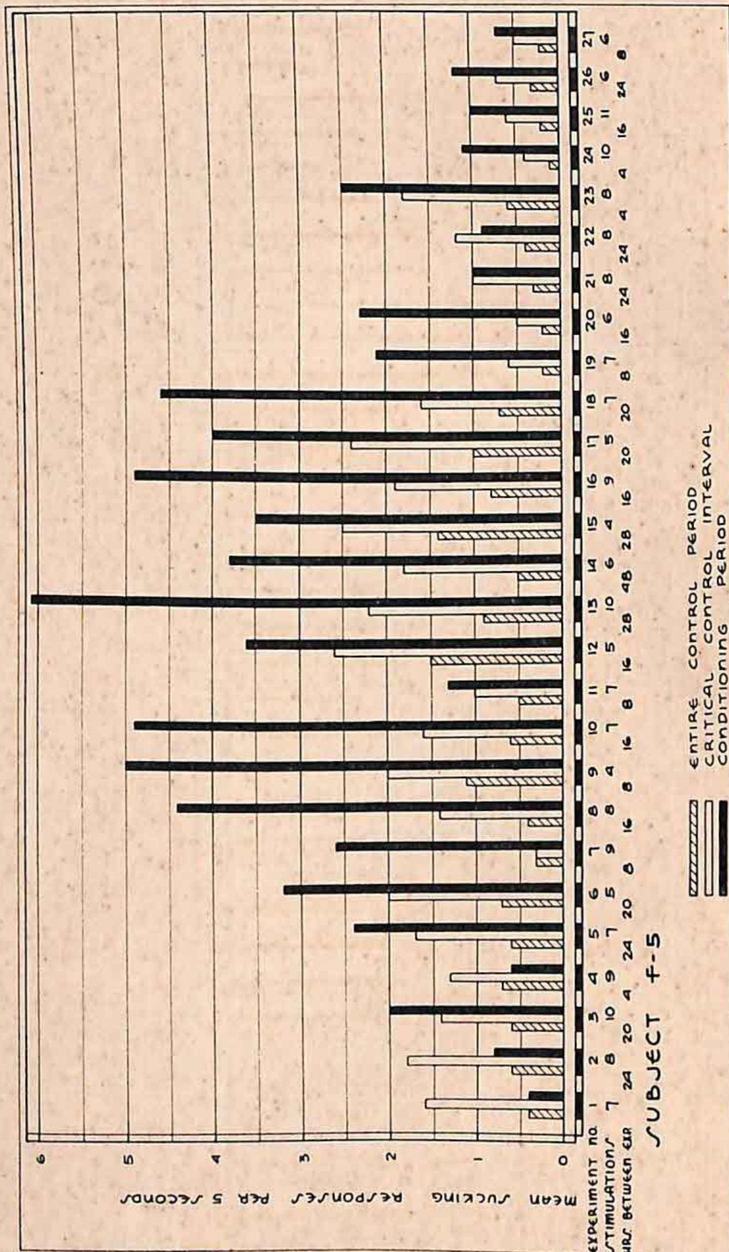

Figure 14. Mean Sucking Responses During Each Experimental Feeding for Subject F5

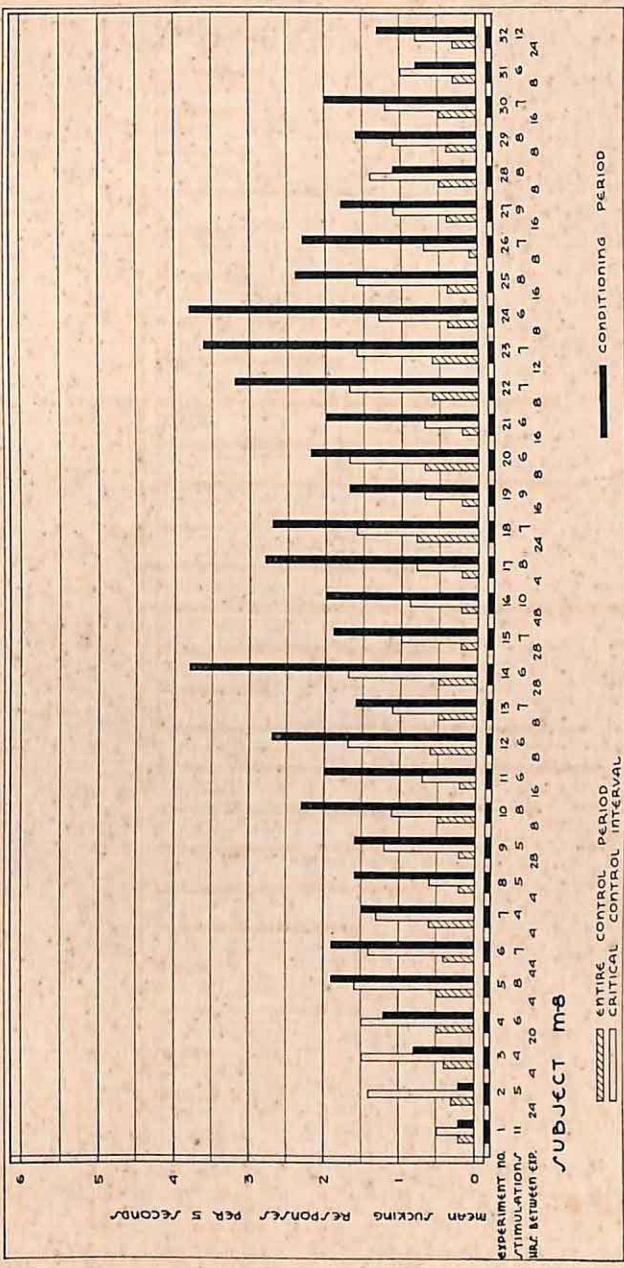

Figure 15. Mean Sucking Responses During Each Experimental Feeding for Subject M8

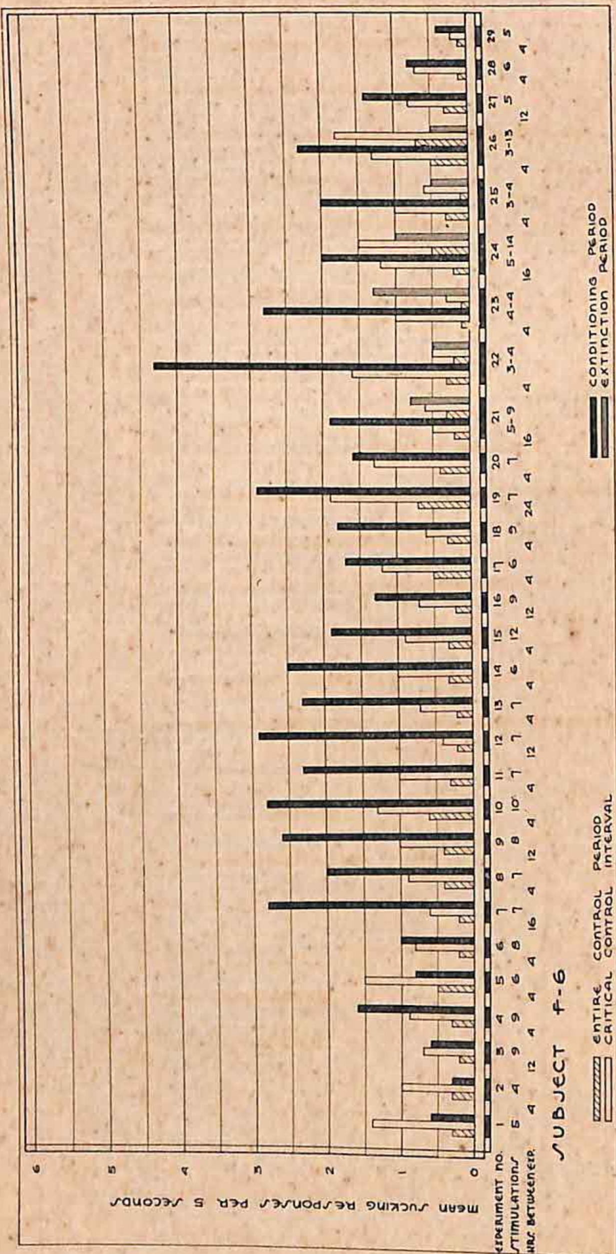

Figure 16. Mean Sucking Responses During Each Experimental Feeding for Subject F6

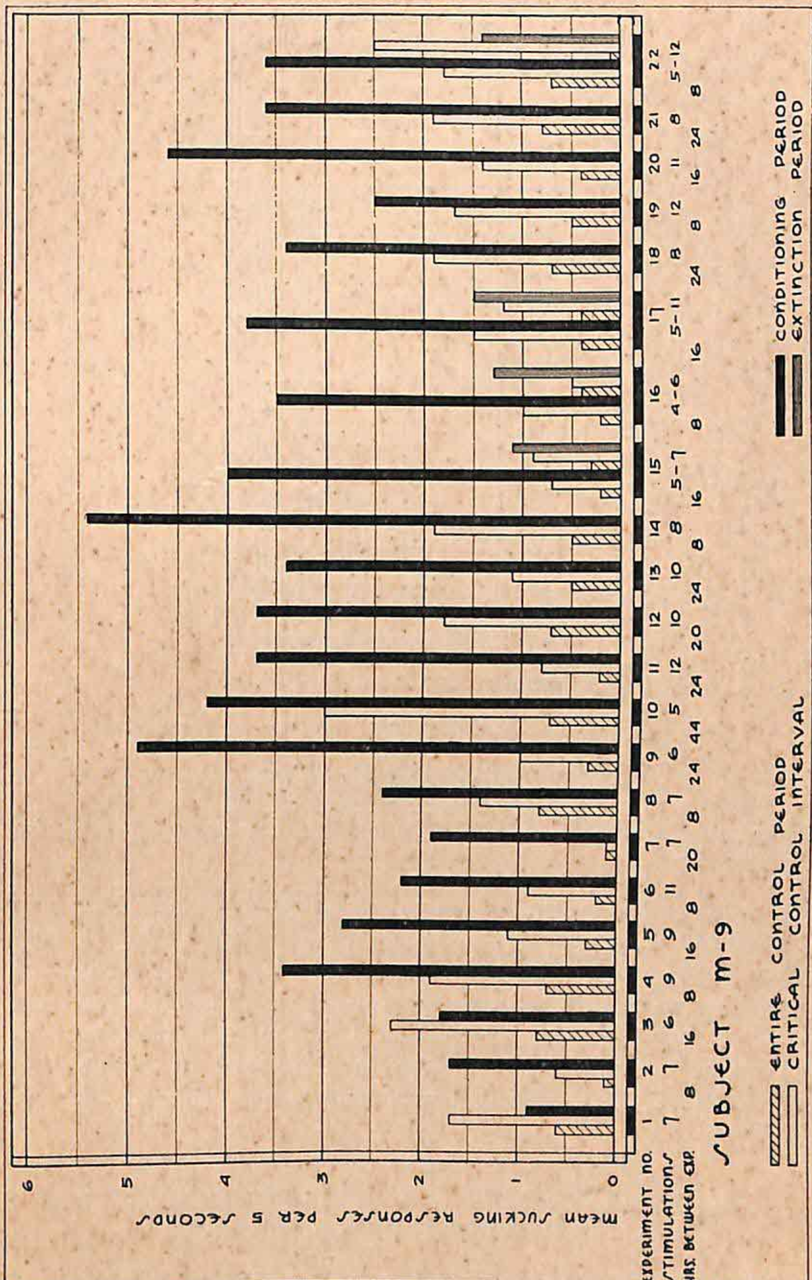

Figure 17. Mean Sucking Responses During Each Experimental Feeding for Subject M9

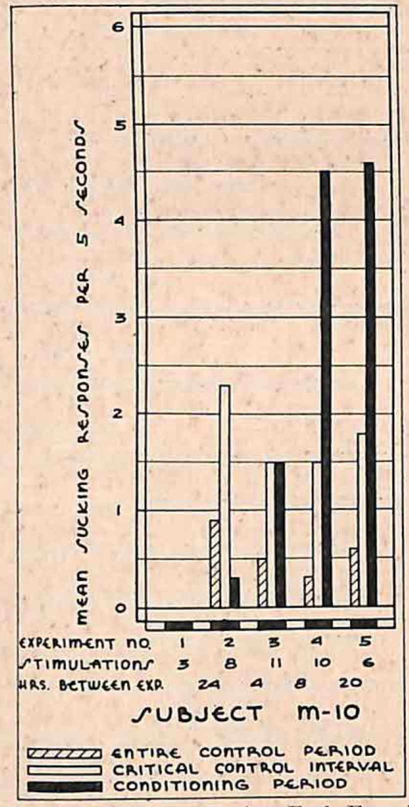

Figure 18. Mean Sucking Responses During Each Experimental Feeding for Subject M10

periments or the number of paired stimulations, bears no reliable relationship to the chronological age of the infant within the age range investigated. The correlations obtained by the method of rank differences are –.43 and .15 respectively. Similar low correlations were obtained between the IQ's and the number of experimental feedings, and between the IQ's and the number of paired stimulations. These correlations were –.05 and –.33 respectively.

Curves of the Acquisition and of the Subsequent Course of the Conditioned Sucking Response

Since the presence of the conditioned response could always be tested for without omitting the unconditioned stimulus, curves of

Table 1

Age at First Experimental Feeding, IQ, Age at Establishment of Conditioned Response, Number of Days, Number of Experimental Feedings, and Number of Paired Stimulations Necessary for the Establishment of the Conditioned Feeding Response

Subject	IQ	Age, Days		Days	Experimental Feedings	Paired Stimulations
		First Experiment	Establishment			
F1	125	44	46	3	6	36
M1		46	46	1	3	16
M2	119	50	51	2	5	30
M3	103	61	63	3	9	53
F2	111	62	64	3	5	33
M4	125	63	65	3	6	38
M5	104	65	66	2	7	42
F3	111	66	67	2	5	31
M6	88	79	81	3	7	72
M7	117	84	85	2	3	19
F4	113	87	90	4	5	50
F5	114	95	99	5	5	41
M8	92	102	104	3	5	34
F6	106	103	105	3	6	41
M9	103	111	112	2	4	29
M10	91	117	118	2	4	32

the acquisition of the conditioned response are not distorted by the interposition of periods of experimental extinction. The rate of acquisition of the stable conditioned feeding response and the course of the conditioned response subsequent to stabilization have been determined. Since it never required more than nine experimental feeding periods to produce a stable conditioned response, a composite curve of the average differences in the amount of sucking between the critical control interval and the conditioning period for the first nine consecutive experiments was obtained from the records of fifteen subjects (Figure 19A). To determine the course which the conditioned response follows after stabilization, a second composite curve was obtained from the records of six infants who had had sixteen consecutive conditioning experiments (Figure 20A). Five infants (Figures 9, 13, 14, 15, and 16) had been subjected to nineteen to thirty-two consecutive conditioning experiments. A Vincent curve (19) has been constructed from the records of these five infants (Figure 21A).

The curve obtained from the results of the first nine experiments exhibits an initial period of accelerated acquisition of the condi-

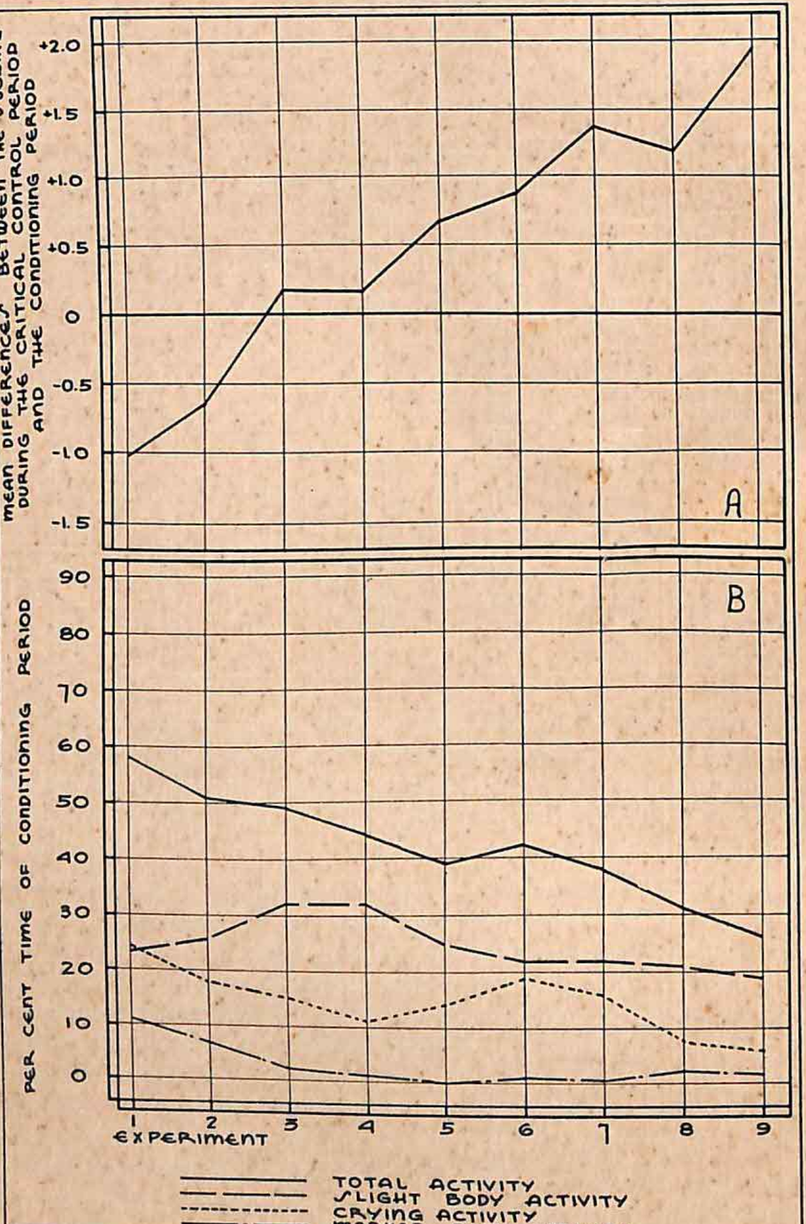

Figure 19. Curves of Sucking (A) and Activity (B) of Fifteen Infants for Nine Consecutive Experiments

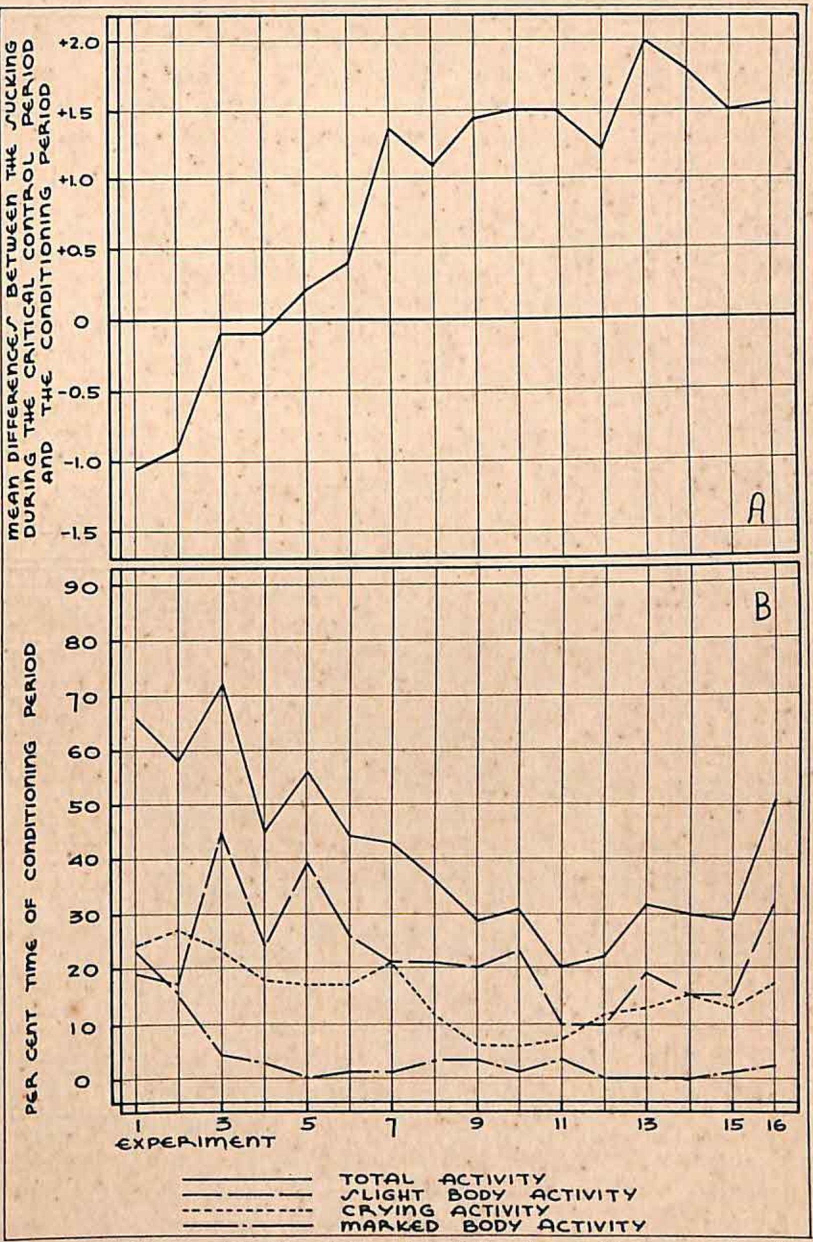

Figure 20. Curves of Sucking (A) and Activity (B) of Six Infants for Sixteen Consecutive Experiments

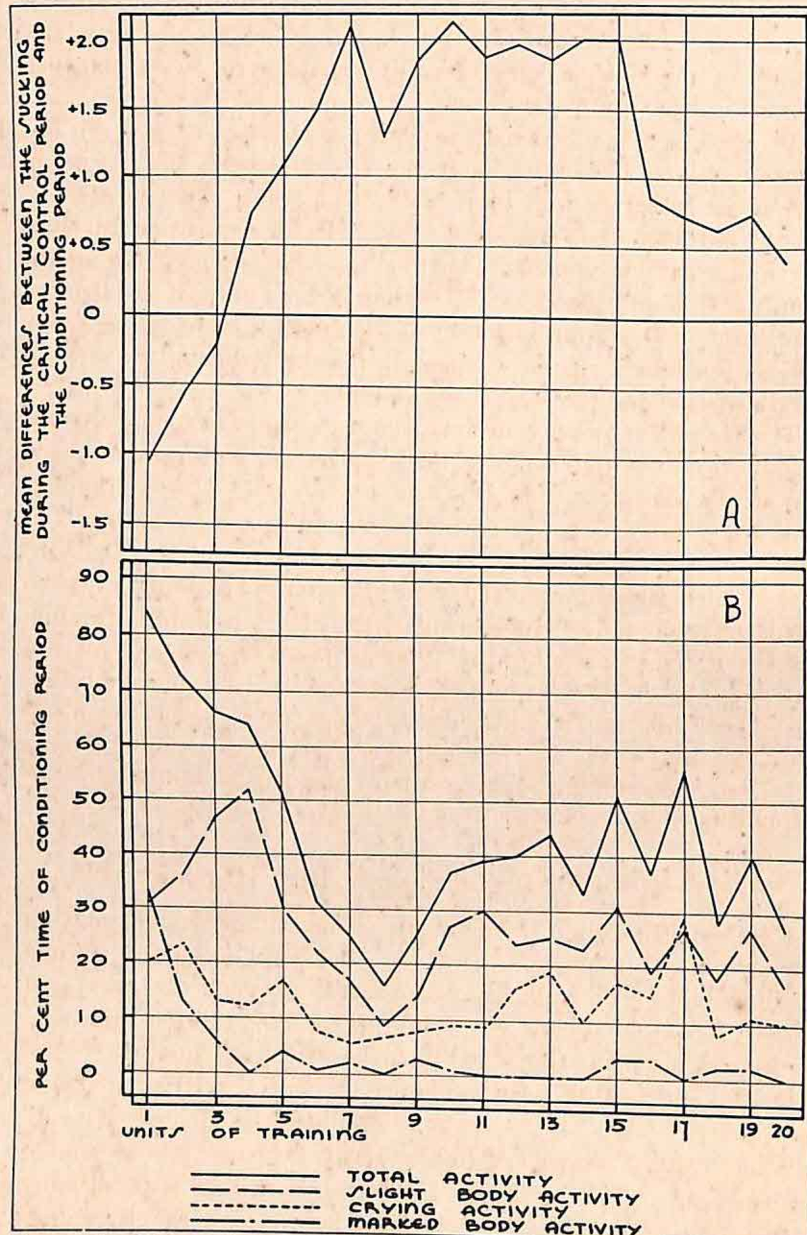

Figure. 21. Vincent Curves of Sucking (A) and Activity (B) for Five Infants

tioned response, which is followed by a relatively constant rate of acquisition. The curve of the rate of acquisition obtained from the results of the sixteen consecutive experiments follows a parallel course until the ninth experiment. Subsequent to the ninth experiment, increased acquisition is no longer evident and the curve becomes relatively horizontal for its entire course, with the exception of a deviation between the twelfth and the fifteenth experiments. It should be noted that the most rapid rate of acquisition in both curves occurs immediately preceding the acquisition of the stable conditioned response. That is, the most rapid rate of acquisition brings the curves approximately to the point at which there is no difference between the mean amount of sucking during the critical control period and the conditioning period.

The records of the five infants who were subjects for more than seventeen consecutive conditioning experiments indicate that there was a new and consistent trend in the progress of conditioning. This trend was characterized by a decrease in the strength of the conditioned response. Until the fifteenth unit of training, the Vincent curve is similar to the curve for the sixteen consecutive experiments (Figure 21A). Subsequent to the fifteenth unit of training, the curve descends from a high plateau to attain a second plateau at a lower level. The rate of descent progressively diminishes until the new plateau is attained. Although there has been an appreciable drop in the degree of conditioning, the new lower level is nevertheless maintained at a position indicative of the presence of a conditioned state.

Concomitant Changes in Behavior During Conditioning

Figures 19B, 20B, 21B show the change of behavioral pattern during the conditioning interval concomitant with the acquisition of the conditioned response. Figure 19B presents the curves of activity observed during the conditioning interval for nine consecutive experiments from the records of fifteen infants. By "total activity" is meant all active and crying behavior. It is noted that total activity bears an inverse relationship to the degree of conditioning. As the amount of total activity decreases, the degree of conditioning increases. A comparison of Figure 19A and Figure 19B will illustrate this statement. This decrement in the percentage of total activity is largely the result of the decreases in the amount of time spent in crying and marked activity. When conditioned

sucking begins to appear at the third experimental feeding (Figure 19A), there is a striking decrease in crying and marked activity associated with an increase in slight activity. This increase in the amount of slight activity is followed by a return to its former level from which point it maintains a relatively unvarying course.

Figure 20B shows the curves of activity for the sixteen consecutive conditioning experiments from the records of six infants. Until the ninth experiment these curves follow essentially the same course as the curves obtained from the nine consecutive experiments. An initial slight decrease and a subsequent progressive increase in total activity is associated with the plateau of the conditioned feeding response which follows the ninth experiment (Figure 20A). Increases in slight activity and crying are largely responsible for the increase in total activity. Marked activity, after becoming almost negligible, maintains its low level.

Figure 21B gives Vincent curves of activity obtained from the records of five infants who were subjects for more than seventeen consecutive experiments. These curves follow essentially the same course as those in Figure 20B until the end of the plateau of the conditioned sucking response is reached (Figure 21A). The decrement in the conditioned response, subsequent to the plateau, is associated with an irregular course of total activity approximating the level attained at the end of the plateau. This irregularity is largely the result of irregularities in the amount of crying and slight activity. Slight activity and marked activity, although displaying irregularities, maintain relatively unchanged positions from those attained at the end of the plateau of conditioning. The amount of crying shows wide fluctuations.

Summary and Discussion

It may be stated, therefore, that accompanying the acquisition of the conditioned response, there are distinct changes in the behavioral pattern, characterized by a progressive diminution in the amount of total activity which is largely the result of marked decreases in crying and marked activity. Subsequent to the attainment of the plateau of the conditioned response, the amount of total behavior does not appear to bear any marked relationship to the degree of conditioning. The decrement of the conditioned response following the plateau is associated with wide fluctuations in the amount

of crying and with irregularities in the amount of slight activity and marked activity.

Kleitman and Crisler (10), Wendt (20), Hilgard (3), Hilgard and Marquis (4), and Marquis (12) have published curves of the acquisition of the conditioned response. The general contour of these curves indicates that the rate of the acquisition of the conditioned response is initially accelerated. This phase is followed by a relatively constant rate of acquisition. The last portion of the curve published by Hilgard and Marquis (4) flattens out to attain a relatively horizontal position demonstrating the level where no further increase is achieved. The data of these authors and of the present investigation indicate that, if conditioning experiments are continued for sufficient lengths of time, they will yield S-shaped curves for the rate of acquisition. A number of experiments have demonstrated that the S-shaped curve is characteristic of the learning of those problems in which the past experience of the subject is of relatively little aid, in contrast to those curves of learning which begin with maximum steepness and proceed with a diminishing rate to reach a plateau. Hull (6) states that the latter curves are probably characteristic of those problems in which the initial adjustments are relatively simple and thus represent only the final portion of the learning sequence, whereas the S-shaped curve is representative of a total learning sequence. The curves constructed from the data of this investigation give additional support to this hypothesis, since the conditioning experiment was a situation in which the past experience of the infant had little or no influence.

The decrement in strength of a conditioned response which was once well established has been reported by a number of investigators. Pavlov (14) has noted that repeated paired stimulations will result in a reduced strength of the conditioned response and finally in a complete disappearance of the response. He believed that with continued presentation the conditioned stimulus takes on inhibitory properties and thus the conditioned response can no longer be evoked by it. Kasatkin and Levikova (9) have reported that after extensive work with two infants, a conditioned feeding response and a differential response diminished considerably in strength. They explained the phenomena on the basis of the loss of spontaneous sucking movements in the behavioral repertoire of the infants. Hilgard (3) has observed the conditioned lid reflex obtained from two human subjects. The rate of acquisition of one subject

was initially accelerated, but after a peak was reached the conditioned response diminished until it could no longer be elicted in spite of continued paired stimulations. He suggested that the decrement is analogous to the effect of repetitive work. Wendt (20) has published a curve of the acquisition of the conditioned knee jerk constructed from the records of one subject. This curve is accelerated reaching a peak at the tenth experiment, from which point the conditioned reflex weakens considerably. The decrement of conditioning in this case was complicated by the introduction of changes in the experimental procedure. Three of the seven subjects used by Newhall and Sears (13) in their investigation of conditioned finger retractions showed large decrements during the last portion of the study. The responses disappeared entirely during the final experimental sittings. These investigators mention the possibility suggested by Hull, that any conditioned reflex may eventually disappear if it possesses no adaptive value for the organism. Wolfle (22), also using the conditioned finger retraction, found reductions in the percentage of conditioning as the experiment was continued. She suggested that the decrement may be due to experimental extinction. Since Wolfle could test for the presence of the conditioned finger retraction only when the unconditioned stimulus was omitted, she was constantly injecting into the reinforcement series the phenomena of experimental extinction. In her investigation and the investigation of Newhall and Sears the explanation of repeated experimental extinction may be tenable.

In the present investigation five infants displayed a marked reduction in the frequency of the conditioned response, despite the fact that each presentation of the conditioned stimulus was reinforced. There are two hypotheses which present themselves as possible explanations for this phenomenon. They are:

1. The loss of the unconditioned spontaneous sucking behavior will result in the loss of the conditioned sucking behavior.
2. The length of the interval between feeding experiments will affect the strength of the conditioned response.

It will be noted in the following tabulation that the number of sucks per five second interval during the entire control period fluctuates inconsistently. One infant shows a marked increase during the tenth to the sixteenth experiment followed by a similarly marked decrease. Two infants show slight progressive increases from the

first through the last experiment. Two infants show progressive decreases from the first through the last experiments.

Subject	Experiment 1 to 9	10 to 16	17 and above
F5	.45	.86	.40
M8	.36	.39	.41
F6	.28	.29	.45
F4	.62	.48	.37
M5	.63	.56	.31

It is evident that spontaneous sucking has not disappeared from the behavioral repertoire of any of these children. In only one infant (F5) does the amount of spontaneous sucking during the entire control period appear to bear a relationship to the degree of conditioning. It remains unlikely, therefore, that the decrement of the conditioned response was greatly influenced by the fluctuations of the unconditioned sucking behavior. This finding is at variance with that of Kasatkin and Levikova (9).

The second hypothesis presents two aspects which are antagonistic. The length of the interval between experimental feedings may be of such an extent that the previously attained degree of conditioning is weakened. On the other hand, frequently repeated experimental feedings after the conditioned response has been stably established may exert an inhibitory tendency upon the response to be elicited. In an attempt to throw light on the first aspect of this hypothesis, an analysis of the records of these five children shows that the hours intervening between experimental feedings, subsequent to the sixteenth experiment, ranged from four to twenty-four hours (Figures 9, 13, 14, 15, 16). With the exception of one infant (Figure 16), these infants had had longer intervals between experimental feedings during the first sixteen experiments. Between the ninth and sixteenth experiments these four infants retained or showed gains in conditioned responses for periods of time ranging from twenty-four to forty-eight hours. Thus, it is demonstrated that at least four of the infants were capable of retaining the conditioned reflex, previous to the sixteenth experiment, for longer periods of time than was demanded of them for the experiments subsequent to the sixteenth.

Since it is demonstrated that the infants previously had been able to retain the response for similar or longer intervals, it would seem that lack of ability to retain the conditioned response was not responsible for the decrement. This fact would lend credence to the

validity of the second aspect of this hypothesis, although the data do not yield conclusive proof. That the effect of frequently repeated experimental feedings may be inhibitory in nature perhaps may be demonstrated by studies of the effect of the introduction of intervals of time of varying length between the experiments after the appearance of the decrement of the conditioned response. The retention of the conditioned response at the maximum level may be dependent upon the spacing of the practice intervals. If the unequivocal truth of this statement were established, it would follow that the optimal spacing of practice intervals is a changing factor dependent upon the stage of the conditioned process.

CHAPTER IV

THE ANTICIPATORY NATURE OF THE CONDITIONED RESPONSE AND OF THE CONCOMITANT BEHAVIOR

It is the purpose of this chapter to describe the acquisition and course of the conditioned feeding response and the concomitant behavioral changes in terms of the temporal situation within the conditioning or buzzer period. All the experiments on fifteen infants, which contained paired stimulations, were divided into three successive groups. The first group consists of those experiments up to the establishment of the conditioned response. The second group represents the subsequent successive experiments during which the frequency of the conditioned feeding responses increases markedly above the level of the critical control interval. The third group represents the final experiments. The frequency of sucking and the character of the behavior were determined for each successive second of the buzzer interval. The means of the feeding responses and the percentage of the time spent in each particular behavior were then computed for each second of the buzzer interval for the three groups of experiments.

Anticipatory Character of the Conditioned Sucking Response

Figure 22 shows the absolute values for the frequency of the sucking responses during the temporal sequence of the buzzer interval. It will be noted that the frequency of the feeding responses for the first group of experiments is greatest during the fifth second of the buzzer interval. This peak of frequency moves in a forward direction, from the fifth to the third to the second in the three groups respectively. This forward movement of the peak of response suggests the anticipatory nature of the conditioned response. That is, the maximal response appearing closer to the onset of the buzzer tone indicates that the conditioned sucking response anticipates to a progressively greater degree the presentation of the unconditioned stimulus, milk.

The values for the frequencies of sucking of the first second of all three groups of experiments are decidedly lower than the values

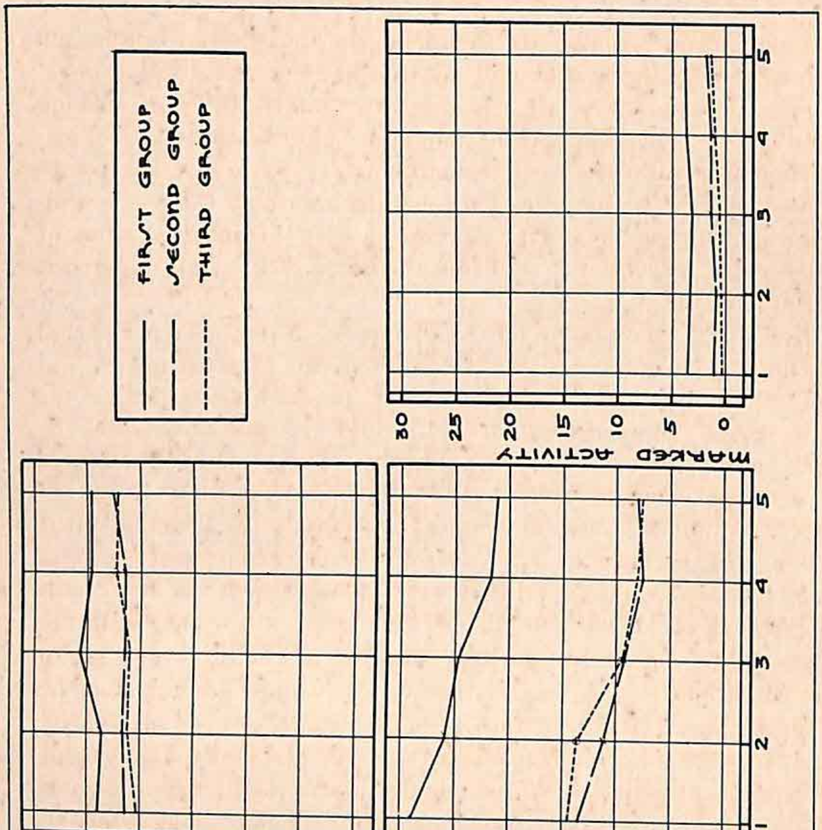

Figure 22. Sucks Per Second and Per Cent Time Spent in Total Activity, Crying Activity, Marked Activity During Each Second of the Conditioning Period for Each Group of Experiments

for the second seconds. It would appear that the low values obtained during the first second are due to an inherent delay in response. When the relative changes in the frequency of sucking between the unconditioned group and conditioned groups of experiments are determined, the anticipatory nature of the conditioned sucking response becomes manifest through the entire temporal sequence of the buzzer interval, despite this inherent delay of the sucking response noted during the first second of all the groups of experiments.

In Table 2 which follows, there are recorded the sucks per second during the buzzer period for the three groups of experiments, and the absolute and relative differences of the sucking responses, for each second, between the first and second groups and between the first and third groups of experiments. The absolute differences represent the actual differences of the frequency of sucking between the first and second groups and between the first and third groups of experiments. The relative differences represent the relation of the above absolute differences to the values of the first group of experiments. Thus the relative differences will demonstrate the changes in frequency of sucking from the unconditioned stage to the conditioned stage, in relation to the values obtained for the former stage. It is seen that the absolute differences in the frequencies of the sucking response between the first and second groups of experiments range within narrow limits for the first four seconds of the buzzer interval, with a much reduced gain being observed during the fifth second. The relative differences, however, decrease

Table 2

Frequency of Sucking During the Buzzer Interval, and the Absolute and Relative Differences of Sucking Between the First and Second and First and Third Groups of Experiments

Buzzer Interval, Seconds	Group			Absolute Difference		Relative Difference	
	1	2	3	Between Groups 1 and 2	Between Groups 1 and 3	Between Groups 1 and 2	Between Groups 1 and 3
First	.13	.45	.38	.32	.25	2.5	1.9
Second	.31	.67	.64	.36	.33	1.2	1.1
Third	.37	.68	.63	.31	.26	.8	.7
Fourth	.37	.64	.60	.27	.23	.7	.6
Fifth	.39	.57	.42	.18	.03	.5	.1

progressively from the first to the fifth second. In terms of the relative differences the anticipatory nature of the response becomes apparent from the onset of the conditioned stimulus. That is, the greater relative increases of sucking at the beginning of the buzzer interval indicate that the conditioned response anticipates the presentation of the unconditioned stimulus, milk, from the onset of the buzzer tone. Although the frequency of the sucking responses of the third group is slightly reduced from that of the second group, the anticipatory nature of the response, in terms of the relative differences of sucking between the first and third groups of experiments, is also very evident.

Anticipatory Character of Behavior During The Conditioning Interval

Two analyses of behavioral changes associated with the conditioning interval have been made. The first to be discussed is the immediate effect of the buzzer on behavior. The behavior immediately preceding and immediately following the buzzer were compared and four qualitative changes were observed: decreased activity, increased activity, no change in active behavior, no change in quiet behavior. In the tabulation which follows, each figure represents the particular behavioral change in terms of a percentage of the total number of buzzer stimulations within the specific group of experiments.

Effect of Buzzer	Per Cent		
	Group 1	Group 2	Group 3
Decreased activity	33.2	44.7	47.5
Increased activity	9.8	2.1	2.9
No change in active behavior	25.2	15.8	17.8
No change in quiet behavior	31.8	37.4	31.8

It will be observed that the buzzer becomes progressively more effective in quieting the behavior of the infant, and conversely, the initiation of increased activity at the onset of the buzzer becomes markedly decreased. These changes indicate that the buzzer tone has acquired a significance which initiates an adaptive form of behavior.

The second analysis is concerned with the behavioral changes within the temporal sequence of the buzzer interval. These changes have been diagrammed in Figure 22. It will be noted that the level of total activity is decidedly lower in the second and third groups

of experiments than in the first. This reduction is, of course, associated with the acquisition of stable conditioning, as was demonstrated in a previous chapter (p. 19), and indicates that conditioning is accompanied by a quieter general behavior of the infant. However, it remains to be demonstrated that when conditioning is established the buzzer tone exerts a relatively greater inhibitory effect on crying behavior within the buzzer interval. The course of the three curves of total activity during the buzzer interval is characterized by a progressive decrement which is almost wholly the result of the decrement in crying behavior. Although the levels of slight activity and marked activity descend from the first to the third groups of experiments, the percentage of time spent in these activities during the temporal sequence of the buzzer remains, to a high degree, constant.

Therefore, crying is the only form of behavior which lends itself to an analysis of behavior within the buzzer interval. Table 3 presents the percentage of time spent crying for each second of the

Table 3

Percentage of Time Spent Crying During the Buzzer Interval, and the Absolute and Relative Differences in the Percentage of Crying Between the First and Second and First and Third Groups of Experiments.

Buzzer Interval, Seconds	Group			Absolute Difference		Relative Difference	
	1	2	3	Between Groups 1 and 2	Between Groups 1 and 3	Between Groups 1 and 2	Between Groups 1 and 3
First	21.4	11.0	13.9	–10.4	–7.5	–.50	–.35
Second	19.2	8.5	11.7	–10.7	–7.5	–.56	–.39
Third	15.9	6.2	7.5	– 9.7	–8.4	–.61	–.53
Fourth	13.3	4.8	4.7	– 8.5	–8.6	–.64	–.65
Fifth	12.6	3.5	4.1	– 9.1	–8.5	–.72	–.68

buzzer for the three groups of experiments, and the absolute and relative differences in the percentage of crying for each second between the first and second groups and between the first and third groups of experiments. The absolute differences between the first and second groups of experiments vary within a narrow range. However, the relative differences of crying increase progressively during the temporal sequence of the conditioning interval. It may therefore be stated that the relative inhibitory effect of the buzzer

on crying behavior becomes progressively greater within the conditioning intervals of the second group of experiments. This progressive and relatively greater inhibition of crying, resulting in almost its complete elimination, is indicative of the anticipatory character of the infant's behavior. The progressive increase in the relative inhibitory effect of the buzzer during its temporal sequence is also evident in the relative differences of the amount of crying behavior during the first and third groups of experiments.

It has been shown that the acquisition of the conditioned response is associated with a progressive movement of the maximal sucking response towards the onset of the buzzer interval, and that the relative gains in the sucking response increase progressively from the fifth to the first second. A study of the qualitative changes of behavior shows that the initiation of the buzzer tone more effectively diminishes the infant's previous activity. Within the buzzer interval there is demonstrated a relatively greater inhibition of crying which results in its almost complete disappearance during the fourth and fifth seconds. The greater relative increase of sucking at the onset of the buzzer and the greater relative reduction of crying leading to its almost complete elimination at the end of the buzzer interval indicate the anticipatory character of the infant's behavior in advance of the presentation of the food.

Anrep (1), Hilgard and Marquis (4), Kleitman and Crisler (10), and Kasatkin and Levikova (8, 9) have observed conditioned responses which were anticipatory in nature. Hull (5) believes that the anticipatory character of the conditioned response is basic in the economical behavior of the organism, for its function is antecedent and preparatory to noxious or beneficial stimulations.

CHAPTER V

THE EFFECT OF HUNGER UPON THE UNCONDITIONED AND CONDITIONED SUCKING RESPONSE

In the course of this investigation it became apparent that the conditioned response was not elicited with uniform strength throughout the entire experimental feeding. The diminishing state of hunger appeared to be at least partially responsible for this phenomenon. It is the purpose of this chapter to demonstrate the validity of this observation.

All the experiments of fifteen infants, which contained paired stimulations, were divided into three successive groups. The first group consists of those experiments performed up to the time of the establishment of the conditioned response. The second group represents the subsequent successive experiments during which the frequency of the conditioned response increases markedly above the level of the critical control period. The third group represents the final experiments in which the maximum level of conditioning is maintained or is slightly reduced. To demonstrate the change in strength of the conditioned response during the experimental feeding, each experiment in all three groups was divided into three parts. As nearly as possible, each third of the feeding experiment contained an equal number of paired stimulations. The means of the frequencies of the sucking response and the amount of concomitant crying behavior during the entire control periods, critical control intervals, and conditioning periods were determined for each third of the experimental feeding of each group of experiments.

Frequencies of Sucking During Course of Experimental Feeding

The results of this analysis are presented in Figure 23. The frequency of sucking during the entire control period is consistently less than that of the critical control interval, and during the three groups of experiments they maintain their same relative positions. In the first group of experiments it will be noted that the frequency of the sucking response during the conditioning period was slightly

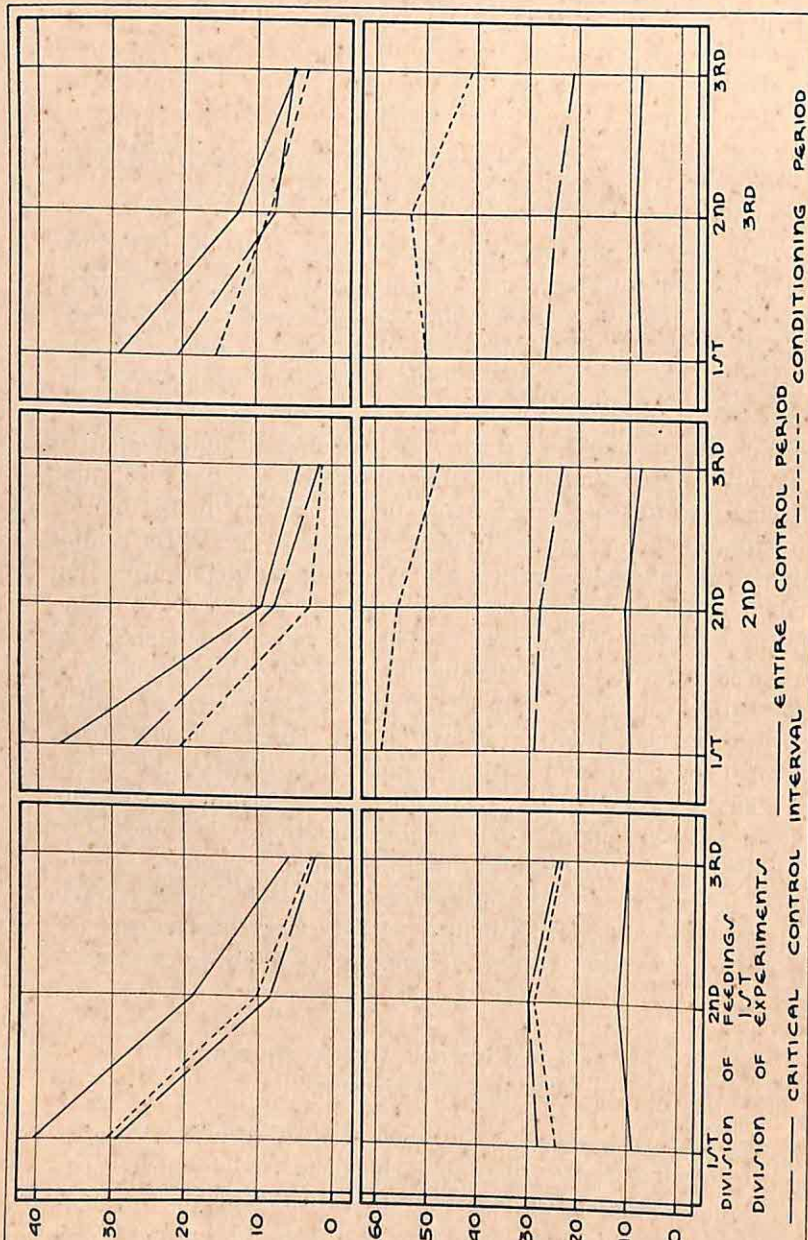

Figure 23. Frequency of Sucking and Per Cent of Time Spent in Crying During the Experimental Feedings of All the Conditioning Experiments

less than that of the critical control interval, and conditioning, as defined previously, had not been established. In the second and third groups of experiments the frequency of sucking during the conditioning periods was much greater than the frequency observed during the critical control intervals. With the exception of the first group of experiments, there is present during the course of the experimental feedings a distinct tendency for the curves of the frequencies of sucking to descend in the critical control and conditioning periods.

Crying Behavior During Course of Experimental Feeding

The curves for the amount of crying (Figure 23) in the three groups of experiments show marked decrements in the course of the experimental feedings, and finally attain similar and extremely low levels. The greatest drop in the amount of crying is noted during the first two-thirds of the experimental feedings. A differential crying response, as manifest by less crying during the conditioning period than during the critical control interval, is evident in the second and third groups of experiments at which time stable conditioning is present.

This marked and consistent decrement in crying would appear to bear a direct relationship to the degree of hunger, which in the course of this experimental situation would undergo a similar decrement. That the negligible amount of crying at the end of all the feeding experiments is approximately the same for the entire control, the critical control, and conditioning periods, whether the conditioned feeding response is present or not, would tend to substantiate the hypothesis that the decrement of crying bears a direct relationship to the decreasing state of hunger and is in no way a function of the conditioning phenomenon.

The Relationship Between the Frequency of Sucking And the Amount of Crying Behavior

The critical control intervals, by definition, represent those five consecutive seconds of the entire control periods containing the most concentrated sucking. It will be observed that the crying during the first two-thirds of the experimental feedings in the critical control intervals is less than the crying noted in the entire control periods. It is evident that during the first two-thirds of the experi-

mental feedings the frequency of sucking during the entire control periods was greatest when the crying behavior was least. It would appear that crying supplants, to an undetermined degree, the feeding response during the first two-thirds of the experimental feedings, and the actual values obtained for the frequency of sucking are less than would be obtained if hunger were not productive of crying. Since the amounts of crying during the last third of an experimental feeding for the entire control, critical control, and conditioning periods are of similar negligible quantities, they would not supplant spontaneous and conditioned sucking to any appreciable degree. Thus the values for the frequency of sucking during the last third of each group of experiments represent more accurately the strength of the unconditioned and conditioned feeding response, uncomplicated by crying behavior.

It may therefore be deduced that the frequency of the unconditioned and conditioned feeding response, if uncomplicated by crying, would bear a direct relationship to the strength of the underlying physiological condition, the degree of hunger. However, the above analysis does not reveal whether the satiation of hunger is associated with the complete loss of the conditioned feeding response. The answer to this problem is to be found in a selective analysis of the feeding experiments.

Analysis of Experimental Feedings in Which Infants Refused Food

With the exception of two experimental feedings from the records of one infant, refusals of the feeding by the infant invariably occurred during the final portion of an experimental feeding. Refusals of the feeding are thus interpreted as indicative of the satiation of hunger. All the experiments, after the establishment of the conditioned response, in which refusals of the feeding were noted, were used in this analysis. There were twenty-six such experimental feedings obtained from the records of nine infants. These experimental feedings were divided into three parts. The last part consists of those paired stimulations associated with refusals of the food. The stimulations previous to the refusals of the food were divided into two equal groups. The values for the frequency of sucking and the amount of crying during the entire control, critical control, and conditioning periods for each division of each experi-

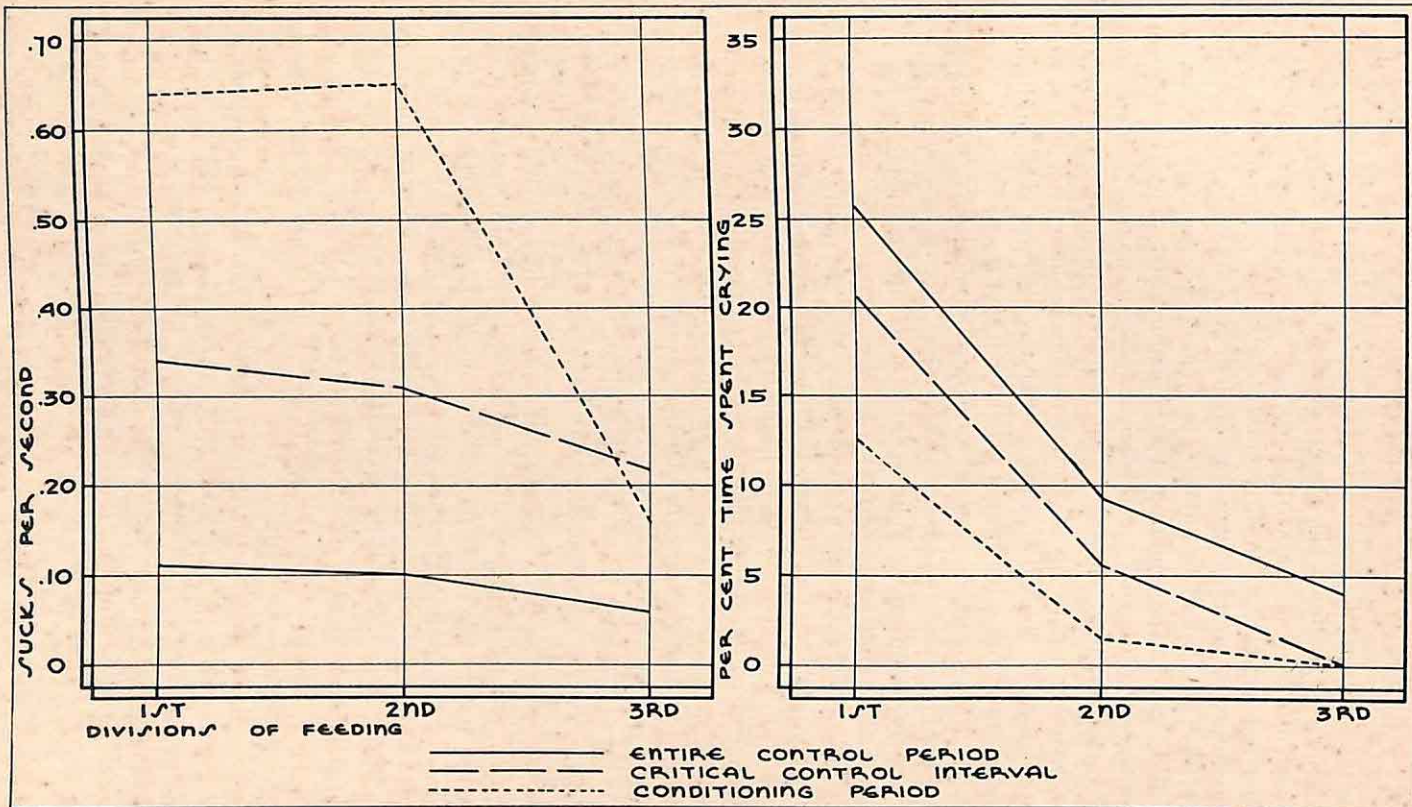

Figure 24. Frequency of Sucking and Per Cent of Time Spent in Crying During the Experimental Feedings Associated With Food Refusals

mental feeding were determined, and the means for this group of experimental feedings were obtained.

Figure 24 shows curves plotted from the above described means. They demonstrate strikingly the effect of the satiation of hunger upon the crying and sucking behavior of these infants. The contours of the curves of crying for this selected group of experiments are similar to the contours observed in Figure 23. Differential crying behavior was present only during the first two parts of the experimental feeding. It should be noted that in this group of experiments crying during the conditioning period and critical control interval descends to a zero level during the last portion of an experimental feeding, at which time the infants were refusing their feedings. That crying supplants sucking during the first two parts of an experimental feeding may be demonstrated here by the same inferences which were used previously (p. 49) in demonstrating this relationship of crying to sucking. Repeating the interpretation previously stated, it may therefore be said that the actual values obtained for the feeding responses are less for the first two parts of the experimental feeding than would have been obtained if crying were not a complicating factor.

The curves of the frequency for sucking during both the entire control and critical control periods show convincingly that which was demonstrated by inference in the similar curves for all the experiments in Figure 23. The curves of sucking for these two periods descend progressively as hunger becomes satiated. The curve for the frequency of sucking during the conditioning period drops precipitously during the last part of the experimental feeding to a point below the level of the critical control period. This striking drop during the last portion of the experimental feeding, when the infants were refusing their milk, is associated with a complete loss of the conditioned feeding response. The frequency of the sucking response during the conditioning period can no longer be differentiated from the response observed during the critical control interval.

That this loss of the conditioned sucking response is not experimental extinction, as defined by Pavlov (14), is readily demonstrated by two facts. The unconditioned stimulus was always offered to these infants, whereas in experimental extinction the unreinforced conditioned stimulus was presented alone. The crying behavior during the unconditioned state has disappeared in these

experiments, whereas the data presented in Chapter VI (p. 52) will show that experimental extinction is associated with marked increases in crying behavior.

It is thus demonstrated that the strength of the unconditioned and conditioned sucking response is a function of the underlying state of hunger, and that the mere contiguity in time of the conditioned and unconditioned stimuli was not sufficient for the production of a conditioned sucking response.

CHAPTER VI

EXPERIMENTAL EXTINCTION

This chapter is concerned with the results obtained when the conditioned stimulus was not reinforced by the unconditioned stimulus. These unreinforced stimuli were presented until no feeding responses were elicited for three consecutive stimulations. This experimental extinction of the conditioned response is one form of the phenomena which has been termed by Pavlov (14) "internal inhibition." Ten infants were subjected to from three to seven experimental extinction studies, each containing four to seventeen unreinforced stimulations.

Rates of Decrement for Successive Experimental Extinction Studies

The results of the first three experimental extinction studies on each infant were combined to form three Vincent curves (Figure 25). It will be noted that the shape of the curve representing the first experimental extinction study presents a reversed S-contour and is essentially a mirror image of the curve for the acquisition of the conditioned response (Figure 19). This reversed S-contour is the result of an initially accelerated rate of decrement of the feeding response which is succeeded by a subsequent relatively constant rate of decrement until the eighth unit of training. The remaining portion of the curve presents a slow descent.

The Vincent curves for the succeeding two studies of experimental extinction differ from the first curve in the following manner. The initial accelerated descent, observed in the first curve, is replaced by progressively steeper descents in which acceleration is not evident. The zero level is attained progressively faster.

The contour of the first curve indicates that the initial adjustment to the extinction situation was difficult. That the repetition of the experimental extinction studies did have an effect upon the adaptive behavior of the infant to the extinction situation is manifest by the progressively steeper initial descents of the curves, indicative of a facilitated initial adaptation to the extinction situation. Further evidence of increased adaptive response to repeated

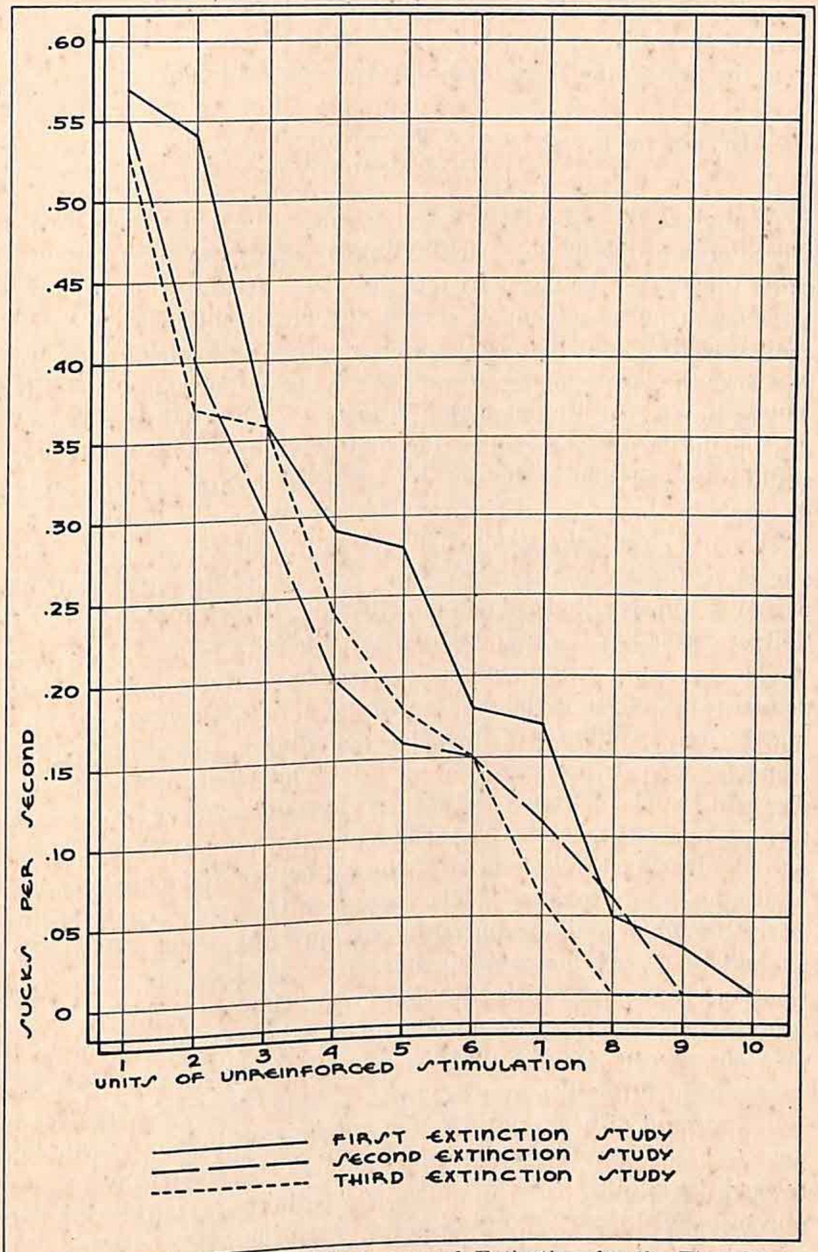

Figure 25. Vincent Curves of Experimental Extinction for the First Three Extinction Studies on Ten Infants

extinction experiments is demonstrated by the fact that the attainment of the fully adapted behavior is reached progressively faster from the first to the third study of experimental extinction.

Effect of Experimental Extinction on Conditioned Sucking and on Behavior

To analyze the progressive effect of the extinction process upon the conditioned behavior, each extinction study was divided into equal thirds and the mean frequencies of the feeding response and the amount of time spent in crying during the entire control, the critical control, and the buzzer intervals were determined. Figure 26 shows the curves of the results of the above determinations. It will be noted that, although the frequency of the feeding response during the buzzer interval of the first one-third of the extinction studies is well above that of the critical control, it ultimately descends in the course of the extinction study to a level below that of the entire control period. This descent of the curve of the frequency of the sucking response below the level of the entire control period would seem to be comparable to what Pavlov (14) has called "silent extinction" or extinction beyond the zero point.

The curves for the amount of crying increase progressively and demonstrate a differential response to the unreinforced buzzer during the first two-thirds of the extinction studies. This differential response becomes progressively less, as is indicated by the marked decrease in the difference between the amount of crying observed during the critical control period and the unreinforced buzzer period. During the last third of the extinction study, the amount of crying is approximately the same for the entire control, the critical control, and the unreinforced buzzer intervals. That the amount of crying increases during the control periods of the extinction studies, at which time food was being withheld from the infant, would tend to substantiate further the statement made in a previous chapter (p. 52) that the amount of crying bears a direct relationship to the degree of hunger. The much greater increases in the amount of crying during the unreinforced buzzer would appear to be the result of this increasing state of hunger and an unrewarded stimulus. The fact that the amount of crying during the unreinforced buzzer is very slightly above the entire control and critical control periods during the last third of the extinction study, and the fact that the velocity of the increase in crying is so much

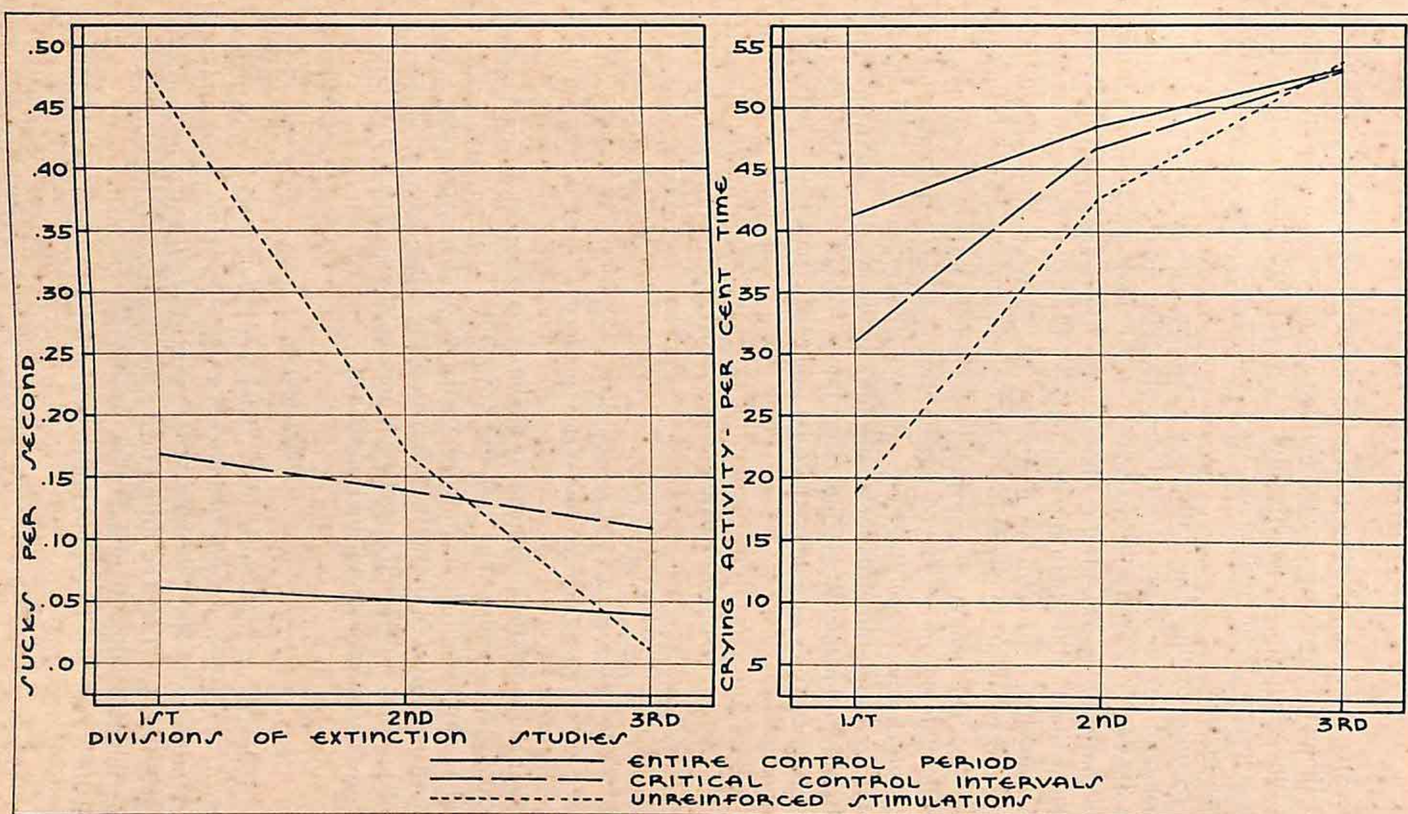

Figure 26. Sucks Per Second and Per Cent of Time Spent in Crying Activity During Extinction Studies

greater than that of either control period, make it appear likely that if the extinction experiments had been continued there would come a time when the unreinforced buzzer would initiate a violent crying response, well differentiated from the crying behavior of either control period.

Studies of the immediate effect of the unreinforced buzzer on the behavior of the infant tend to substantiate further the above hypothesis. An analysis was made of the immediate effect of the second and last unreinforced buzzer upon the behavior of the infant. The second rather than the first buzzer was chosen for this analysis, because the anticipatory nature of the conditioned response precludes the use of the first unreinforced stimulation in the extinction series. The behavior immediately preceding and that immediately following the unreinforced buzzer were compared and four qualitative changes were observed: decreased activity, increased activity, no change in active behavior, and no change in quiet behavior. In the following tabulation each figure represents the behavioral change as a percentage of the total number of extinction studies.

Effect of Buzzer	Percentage Second Unreinforced Buzzer	Percentage Last Unreinforced Buzzer
Decreased activity	49.0	4.6
Increased activity	4.6	18.6
No change in active behavior	20.8	65.2
No change in quiet behavior	25.6	11.6

That the immediate response to the buzzer has significantly changed from the second to the last unreinforced buzzer is very evident. The stimulus which at the onset of the extinction study had for the most part quieted the active behavior of the infant subsequently had little effect upon active behavior and initiated increased activity more frequently than it had previously.

Discussion

Hilgard and Marquis (4), Kleitman and Crisler (10), and Switzer (18) have published curves of the rate of decrement during extinction studies. These curves support the hypothesis made previously (p. 49) that the initial adjustment to the first extinction experiment is difficult and is thus productive of a curve which presents a reversed S-contour and is essentially a mirror image of the

curve of the acquisition of the conditioned response. Pavlov (14), Kleitman and Crisler (10), Switzer (18), and Jones (7) have presented evidence that repeated extinction studies result in a more rapid extinction of the conditioned response and would tend to support the hypothesis that with repeated experimental extinctions the reversed S-shaped contour of the curve of the first extinction study is replaced by a contour in which there is no initially accelerated descent. The initial descent of these latter curves would be steeper and of a constant rate.

That extinction is not forgetting is readily noted by an inspection of Figures 3, 5, 6, 7, 8, 10, 11, 12, 16, 17, where it will be seen that spontaneous recovery of the conditioned response occurred after each extinction experiment. Hull (6) has pointed out that experimental extinction cannot be considered a defect in the learning process but rather an adaptive form of behavior. It may be considered the basis for the discarding of false leads, that which Stoddard and Wellman (17) call "economy," one of the characteristics of intelligent behavior.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Using the technique of the conditioned response, this investigation was designed to analyze the organization of early adaptive behavior in young infants. The spontaneous sucking behavior of sixteen infants ranging in age from six to fourteen weeks was conditioned to the sound of a buzzer. The data consist of objective records of sucking and of protocols of behavior. Subsequent to the establishment of the stable conditioned response, studies of experimental extinction were made.

The establishment of the stable conditioned response required three to nine experimental feedings which contained sixteen to fifty-three paired stimulations. With the procedure employed in this experiment, it required one to five days to establish stable conditioning.

Curves of the rate of acquisition of the conditioned response are found to be S-shaped. When experimental conditioning was continued after the maximal level of response had been attained, a decrement in the degree of conditioning was observed. The data suggest that the maintenance of the maximal level of conditioning is dependent upon the proper spacing of practice periods. The data of this investigation substantiate the hypothesis that the S-shaped curve is characteristic of a complete learning process, in which past experience is of little or no influence.

Accompanying the acquisition of the conditioned sucking response, there were observed distinct changes in the behavioral pattern of the infants. These changes were characterized by a marked decrease in total activity. The decreases in crying and marked activity largely accounted for the decrease in total activity. No distinct change in behavioral pattern was noted concomitant with the decrement in the conditioned response.

The progressive inhibition of crying during the conditioning interval and the appearance of the maximal sucking response closer to the onset of the conditioning interval, as experimental feedings were continued, demonstrated the anticipatory character of the conditioned response. The elicitation of a specific form of behavior by

a nonspecific stimulus, antecedent to the presentation of the specific stimulus, demonstrates the economy of the organism by the utilization of significant signals in its preparation for the situation to follow.

The strength of the unconditioned and conditioned sucking response was found to bear a direct relationship to the degree of hunger. The satiation of hunger is associated with a complete loss of the conditioned sucking response. As the degree of hunger diminishes, the degree of differential crying behavior decreases. These data demonstrate that mere contiguity in time of the conditioned and unconditioned stimuli is not sufficient for the production of a conditioned sucking response in infants. In these subjects the underlying physiological state, the degree of hunger, which is common to both the unconditioned and conditioned responses, may be considered the motivating factor. The above results demonstrate the extremely important role played by motivation in these conditioning experiments.

Curves of the rate of decrement of the conditioned response obtained from the first experimental extinction study present a reversed S-contour. This reversed S-contour is essentially a mirror image of curves of the rate of acquisition of the conditioned response. The curves of the rate of decrement for the succeeding extinction studies show that repetition of the extinction situation facilitates the inhibition of the conditioned response. The curves for these subsequent extinction studies do not present a reversed S-shaped contour because the initially accelerated rate of decrement of the first extinction study is replaced by a greater and more constant rate of decrement.

The behavioral pattern undergoes marked changes in the course of an extinction study. These changes are characterized by a progressive increase in the amount of time spent in crying. Crying during the conditioning interval increases at a much greater rate than does crying during the control periods. Throughout the last part of an extinction study crying during the conditioning interval tends to exceed the crying during the control periods. These data suggest that if unreinforced stimulations were continued, they would elicit a violent crying response, well differentiated from the crying behavior of the control periods.

Here, as with anticipation, the economy of the organism is manifest. The infants of the present investigation exhibited the capacity

to utilize significant signals and to discard false leads, activities which are found, in more complex forms, in the adaptive behavior of children and adults. Thus infants less than four months of age demonstrate some activities which are characteristic of intelligent behavior.

The conditioned reflex technique is a valuable aid in the elucidation of the basic mechanisms of intelligent behavior. The findings of this investigation point to several factors which deserve more intensive study. These factors are either the result of changes in the experimental procedure or of changes within the organism itself.

The ability to discern changes in the experimental procedure is, of course, exemplified by the study of experimental extinction where a major change is instituted. Further studies of less obvious changes in the experimental procedure are desirable. Such studies would include investigations of the ability to differentiate two stimuli, one receiving reinforcement and the other receiving none, and also investigations of the spread of inhibition of response to stimuli associated with a stimulus that has already acquired inhibitory properties. The effect of changing the quality of the unconditioned stimulus should yield fruitful results.

It seems desirable that the factors within the organism which influence the conditioned state be studied more intensively. This investigation has demonstrated the extreme importance of the state of hunger in conditioned feeding responses. An elucidation of other underlying physiological states which may be operative in the elicitation of other conditioned responses in infants is indicated.

Finally, an analysis of those factors which are responsible for the decrement of the conditioned response subsequent to its maximal attainment may throw light on some of the conditions which are necessary for the maintenance of maximal conditioning.

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